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// THE ELECTRICAL AGE

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Water Power in South Africa

Electricity from Victoria Falls

By FRANCIS FOX

IN November, 1855, when Dr. Livingstone and Mr. Oswell reached the Zambesi, the wondrous falls of that river were, for the first time, looked upon by European eyes, and these British travelers gave to them the name of the much lamented Queen. They had often heard of the falls, known by the natives as "Mosi oa tanya" ("Smoke does sound there") since they first entered their country; but the exact locality was not accurately known. In fact, the natives regarded the falls with such awe that they viewed them only from a distance, whence they could observe the great columns of spray and hear the distant roar as the cascade fell into the stupendous gorge. In their simplicity the natives supposed that the spray was smoke, and they asked Dr. Livingstone whether in his country there was such a thing as "smoke that sounds."

It is a remarkable fact that, in well-executed maps based on Portuguese discoveries, dated 1662, copies of which are to be seen in the British Museum, the general course of the river "Zambere," which doubtless is the same as "Zambesi," is shown, and the position also of gold and diamond fields is indicated; and not only the sources and course of the Blue and White Niles and the two large lakes or Nyanzas from which they flowed, but also the river Zaire or Congo flowing out from a lake and making its great bend by the Aruimi, whilst on the other hand, a mythical statement appears thereon to the effect that in Tanganzika or "Zaire Lacus," as it was then known, "Tritons, Mermaids and Sirens are said to be." The great discoveries of Speke and Grant, of Livingstone, Baker, and Stanley, were, in fact, re-discoveries of things which had been ascertained and mapped out by the Portuguese and afterwards lost.

Approaching the falls from the north, Dr. Livingstone's description of his visit is well worth recording:—

"After twenty minutes' sail from Kalai, we came in sight, for the first time, of the columns of vapor, appropriately called 'smoke,' rising at a distance of five or six miles, exactly as when large tracts of grass are burned in Africa. Five columns now arose, and, bending in the direction of the wind, they seemed placed against a low ridge covered with trees; the tops of the columns at this distance appeared to mingle with the clouds. They were white below, and higher up became dark, so as to simulate smoke very closely.

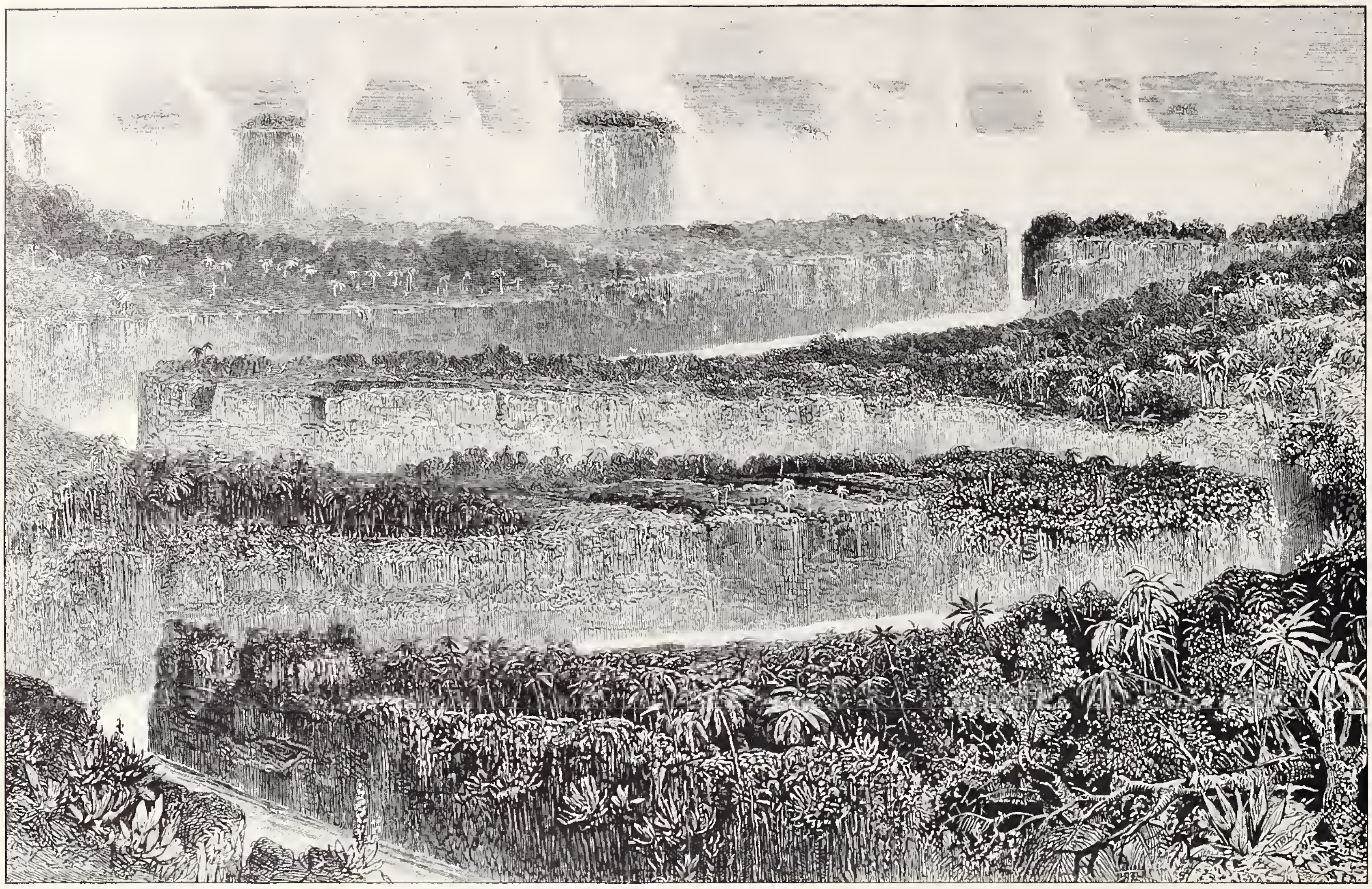
"The whole scene was extremely beautiful: the banks and islands dotted over the river are adorned with sylvan vegetation of great variety of color and form. But, though we had reached the island in the middle of the falls, and were within a few yards of the spot, a view from which would solve the whole problem, I believe that no one could perceive where the vast body of water went; it seemed to lose itself in the earth, the opposite lip of the fissure, into which it disappeared, being only 80 feet distant. At least I did not comprehend it until, creeping with awe to the verge, I peered down into a large rent, which had been made from bank to bank of the broad Zambesi, and saw that a stream of a thousand yards broad leaped down a hundred feet, and then became suddenly compressed into a space of fifteen or twenty yards. The entire falls are simply a crack made in a hard basaltic rock from the right to the left bank of the Zambesi, and then prolonged from the left bank away through thirty or forty miles of hills.

"In looking down into the fissure on the right of the island, one sees nothing but a dense white cloud, which, at the time we visited the spot, had two bright rainbows on it. From the cloud rushed up a great jet of vapor exactly like steam, and it mounted 200 or 300 feet high; there condensing, it changed its hue to that of dark smoke, and came back in a constant shower, which soon wetted us to the skin. This shower falls chiefly on the opposite side of the fissure, and, a few yards back from the lip, there stands a straight hedge of evergreen trees, the leaves of which are always wet. From their roots a number of little rills run back into the gulf; but, as they flow down the steep wall there, the column of vapor, in its ascent, licks them up clean off the rock, and away they mount again. They are constantly running down, but they never reach the bottom.

"I saw the falls at low water, and the columns of vapor, when five or six miles distant. When the river is full, or in flood, the columns, it is said, can be seen ten miles off, and the sound is quite distinct somewhat beyond Kalai, or about an equal distance. No one can then go to the island in the middle."

As soon as the "Trans-continental," or "Cape to Cairo" Railway, which is already running as far as Bulawayo, and is practically completed for 100 miles beyond, reaches the falls, the survey and preliminary works for a great installation of electric power plant will commence.

The accompanying illustrations of



A BIRD'S-EYE VIEW OF THE GREAT CATARACT OF THE ZAMBESI AND OF THE ZIG-ZAG CHASM BELOW THE FALLS THROUGH WHICH THE RIVER PASSES OFF

(By permission of Mr. John Murray, London.)

the various portions of the Victoria Falls will, in conjunction with the two maps which show the comparative widths of the Niagara and Victoria Falls, serve to give some idea of their magnitude. In the Niagara River there are two falls, the American Fall, and the Canadian, or Horse-Shoe, Fall, separated by Goat Island, the entire width being about half a mile. The total height is from about 158 to 167 feet, and the estimated average horse power running to waste is 7,000,000.

In the case of Victoria Falls there are three islands, the center one known as Livingstone Island, as it was here that the doctor planted a number of fruit trees, all of which were destroyed by the hippopotami. The entire width is about a mile, the height of the falls is from 400 to 420 feet, and when the river is in flood it is estimated that the volume of water is about double that of Niagara, giving about 35,000,000 H. P. as running to waste. During the dry season this is much reduced; but, even in the dryest years, the volume passing over the lip is very large. One of the most remarkable features of the place is the gorge, which is entirely cut out of basalt, and runs zigzagging for many miles. Of this an excellent photographic reproduction is given on page 2.

The "Cape to Cairo" Railway will traverse the peninsula of rock immediately in front of the falls, and will cross the gorge by the bridge shown on page 5. The clear span of the arch of this bridge will be 500 feet, and the height, 400 feet above the river, in consequence of which no staging nor scaffolding can be employed in its erection. The proposed bridge is intended to be built out from each bank of the ravine, on the cantilever principle, until the steelwork of the arch meets in the center. The width of the bridge will be sufficient for a double line of railway, and on a lower level provision will be made for the addition at a future date of a roadway for vehicles and pedestrians, thus affording a much-needed communication across the Zambesi.

The actual position of the town, which will inevitably spring up adjacent to the falls, has not yet been definitely decided; but it will probably be on the south side, and here will be built a suitable hotel, for the accommodation of traders and travelers, and to which visitors will, doubtless, flock from all parts of the world.

Some time ago the falls were visited by Sir Charles Metcalfe, Bart., who, with Sir Douglas Fox, is one of the consulting engineers to the British South Africa (Chartered) Company. Upon his return from the falls he communicated his impression of their possibilities to the late Right Hon. Cecil Rhodes, and the latter, with his usual receptivity of large ideas, at once took action in the matter, and initiated the arrangements now in progress for utilizing the power.

Before describing generally what is intended to be done to utilize the power by harnessing some portion of the falls, it will be desirable to ascertain what has already been accomplished in other places up to the most recent date. Electrical science is developing with such giant strides that even the last two years have produced unlooked-for results.

The two great questions which have to be answered are, first, to what distance can electrical energy be transmitted with practical and economical results; and second, what is the limit of voltage which can be adopted in various climates?

In the United States the application of water power has been largely developed. The works of the Niagara Falls Power Company at present provide 50,000 H. P., upon which practically 500,000 people are dependent in

Niagara, Lockport, Tonawanda, and Buffalo. The current, generated at 2200 volts, is transmitted at a pressure of 22,000 volts by overhead transmission lines to a point 35 miles distant, the loss in transmission, including step-up and step-down transformers, being about 12½ per cent.; but for local distribution, where underground cables are requisite, 10,000 volts are the maximum pressure at present adopted. This installation is now being increased to secure a total of 110,000 H. P.

When one considers the various purposes to which electric power is applied in the Niagara district, it is at once apparent that in a highly mineralized country, such as Rhodesia, the applications of electricity will, in due time, be almost numberless. At present the power of Niagara is used for the following purposes amongst others, in many of which the electric furnace plays an important part:—The manufacture of aluminum; operation of water works, alkali works, and carborundum and graphite works; acetyvone manufacture; electric lighting; reduction of ores; manufacture of flax fiber; electric railways; lead reduction; in operating a natural food factory; a hook and eye factory; carbide works; chemical works; emery-wheel factory; switch and crossing works; paper factory; pulp factory; and biscuit factory. The possible applications are capable of almost unlimited extension.

It may be well to point out wherein lies the great advantage of the electric furnace. In an ordinary furnace supplied with coal, coke, or wood fuel the heat depends upon an ample supply of air, with its component of 23 per cent. of oxygen. The more air, the fiercer the heat; but, in the electric furnace, neither oxygen nor air is required to produce the highest temperatures, such as are unattainable by any other known means, and consequently the furnace, which is closed so that air cannot enter, may be supplied with any combustible matter found to be the most eligible for the particular process in hand. Perhaps an exception should be made of "thermite," in which aluminium is used for reducing, in a simple and expeditious manner, the most refractory ores of such metals as chromium, cobalt and tungsten, provided that they are in the forms of oxides.

The most familiar instance of an electric furnace is the ordinary electric incandescent lamp. In this a fine filament of charcoal is heated to a glowing incandescence by the electric current. Were it exposed to air, it would instantly be consumed; but, being in a high vacuum, it cannot burn.

A PORTION OF THE GORGE BELOW THE FALLS

In like manner the most inflammable material, phosphorus, which will burst into flame when exposed to a temperature of only 55° C., can be reduced and its vapor can then be raised to a temperature of 1500° to 2000° C. without combustion, by keeping the furnace supplied with carbon, so that there is nothing with which it can combine.

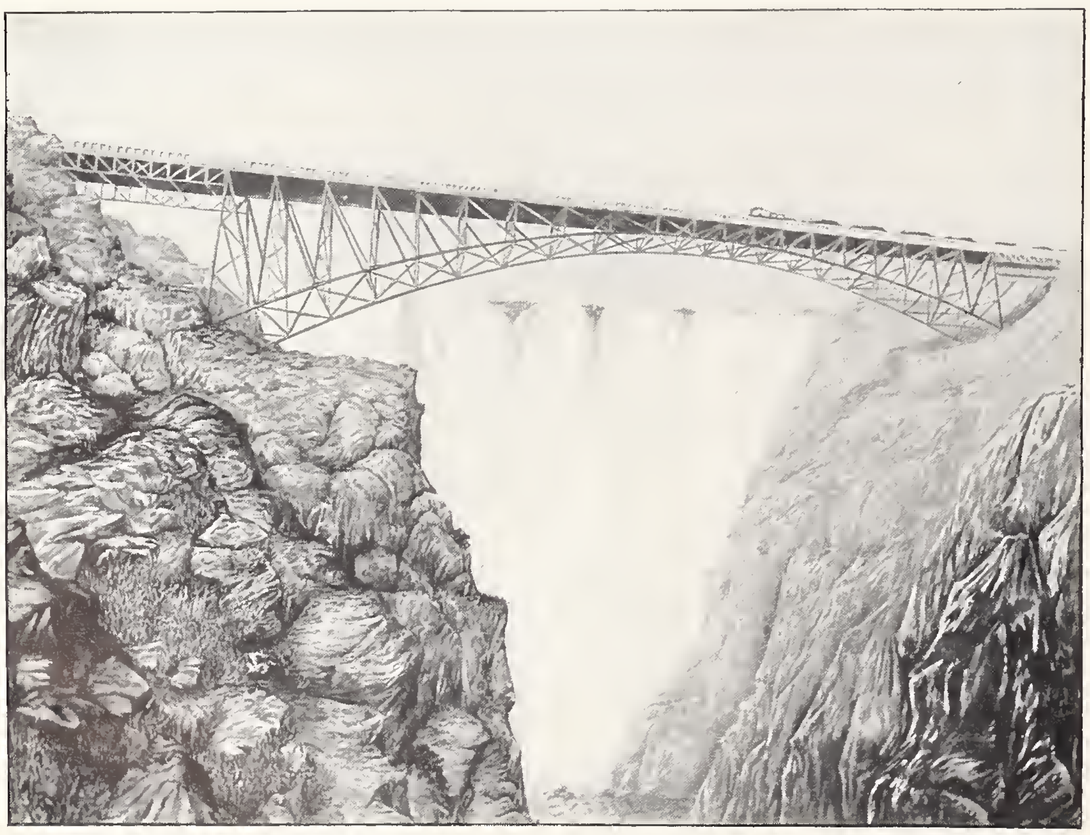
It is probable that the highest temperature attainable from fuel is about 2000° C., whereas the theoretical temperature available in the electric furnace is about 18,000° C. Chemical reactions at high temperatures have only within the last ten years been practically attained, and an unlimited field for investigation and for employment is thrown open by the development of the science of electro-chemistry. Take, for instance, the manufacture of carbide of calcium,—a product which was discovered quite by accident; or of carborundum, for obtaineach beginning with the letter S, namely, sand, sawdust and salt, are mixed in certain proportions and placed in a suitable furnace. After passing the Niagara current through the charge for fifteen hours, the product is a mass of crystals of metallic lustre and of beautiful form, with a degree of hardness ranking next to the diamond. The material is used as an abrasive, much in the same way as is emery.

Electrical energy can also be applied with great advantage to pumping water out of mines, ventilating underground workings, hauling of wagons from the deep levels, driving

THE "BOILING POT." HERE ALL THE WATER OF THE FALLS IS CONCENTRATED IN ITS ESCAPE

VICTORIA FALLS, SHOWING LIVINGSTONE ISLAND IN THE MIDDLE

drills,—in fact, doing a wide variety of work. Hitherto in deep mines, in which water has been encountered in quantity, the shaft is largely occupied by the heavy pumping rods and gear, which machinery not only encumbers the available space, but also is wasteful, because of the reciprocating movement of the various parts. Since the introduction of the admirable system of centrifugal high-lift pumps the shafts where they have been adopted have been cleared of pumping machinery, the only remaining parts being the necessary rising main, and an electric cable.



THE PROPOSED BRIDGE OVER THE ZAMBESI RIVER AT VICTORIA FALLS, ON THE RHODESIA RAILWAY. SPAN, 500 FEET; HEIGHT, ABOVE WATER, 400 FEET

The silver mines of Horcajo, in Spain, have gathered round them a population of 5000 people. The depth at present is 1280 feet, which is being increased about 18 feet a year, the total future depth being placed at 1640 feet. The pumping is done by high-speed, compounded, centrifugal pumps, driven electrically. Each pump, on an average, lifts through about 400 feet, and this arrangement has solved the important problem of how the mine was to be unwatered.

Formerly, powerful Cornish pumping engines had been fixed at great expense, and had proved both costly and unsatisfactory in working; but, by the adoption of centrifugal pumps, all spears and rods have been dispensed with, all reciprocating motion has been avoided, and the ascending column of water is kept in constant motion, thus avoiding the serious hydraulic blows which formerly burst the strongest pipe.

At a large colliery in South Durham spear rod pumps, lifting 1000 gallons per minute against a head of 400 feet, have been removed, and three-throw pumps, electrically driven, have been substituted, effecting a saving of $7500 a year. In Northumberland and Scotland similar changes have been effected, with economies of $9000 and $15,000 a year, respectively.

For hauling and winding engines the advantages of electric power are great, obviating the necessity for engines, boilers, chimneys, and fuel. Electrically-driven fans for ventilation, and electric pumps, can be placed in the most remote parts of a mine. The advantages will specially be appreciated by all who have had practical experience of mining, and who know the serious problem of raising water, or of extracting vitiated air from the dip levels of deep mines.

In a certain mine, in a far-off dip level, an electric pump is fixed, which is actuated from the power house at the surface; there a telephone is attached, by which the engineer in the power house can ascertain whether the pump is at work and acting properly without the necessity of a man being in constant attendance.

But whilst upon this subject of mining, it is desirable to call attention to the very serious results occuring to the employees of a mine, from the dust produced by the drills used in driving the advance galleries and in the stopes. In the copper mines of Cornwall and in the gold mines of Johannesburg the gravest results are produced upon the men; hence the reason for so many miners being consumptive. It is a well-known fact that the life of a miner in charge of an advance heading is short; consequently the pay is high, and it is not uncommon for a foreman in charge to be paid $500 a month. The writer has personal knowledge of one case in which a gang of sixteen Cornish miners, fine, stalwart fellows, in charge of a certain heading or driftway, all died from consumption in a comparatively short time. Such occurrences naturally make white men reluctant to enter the mines, even if highly paid; and this accentuates the labor problem on the Rand.

The Chamber of Mines at Johannesburg have offered three prizes, one of $2500 and a gold medal, one of $1250, and one of $500, for the best device for ridding the mines of dust, and thus reducing the present heavy loss of life from "miners' phthisis." Hitherto a remedy for this trouble has not been forthcoming, but this excuse can no longer be pleaded. In the Simplon tunnel, in course of construction through the Alps, the length of which is 12½ miles, the Brandt hydraulic drill is working with the greatest success; no dust is produced in the advance galleries, splendid ventilation is provided, and the rate of progress has completely beaten the world's record. Headings, 10 feet in width and 8 feet in height, are driven through gneiss, and other very hard rock, at a speed of over 700 feet a month, and in one case of 770 feet, without injury to health or life and much diminished cost of driving.

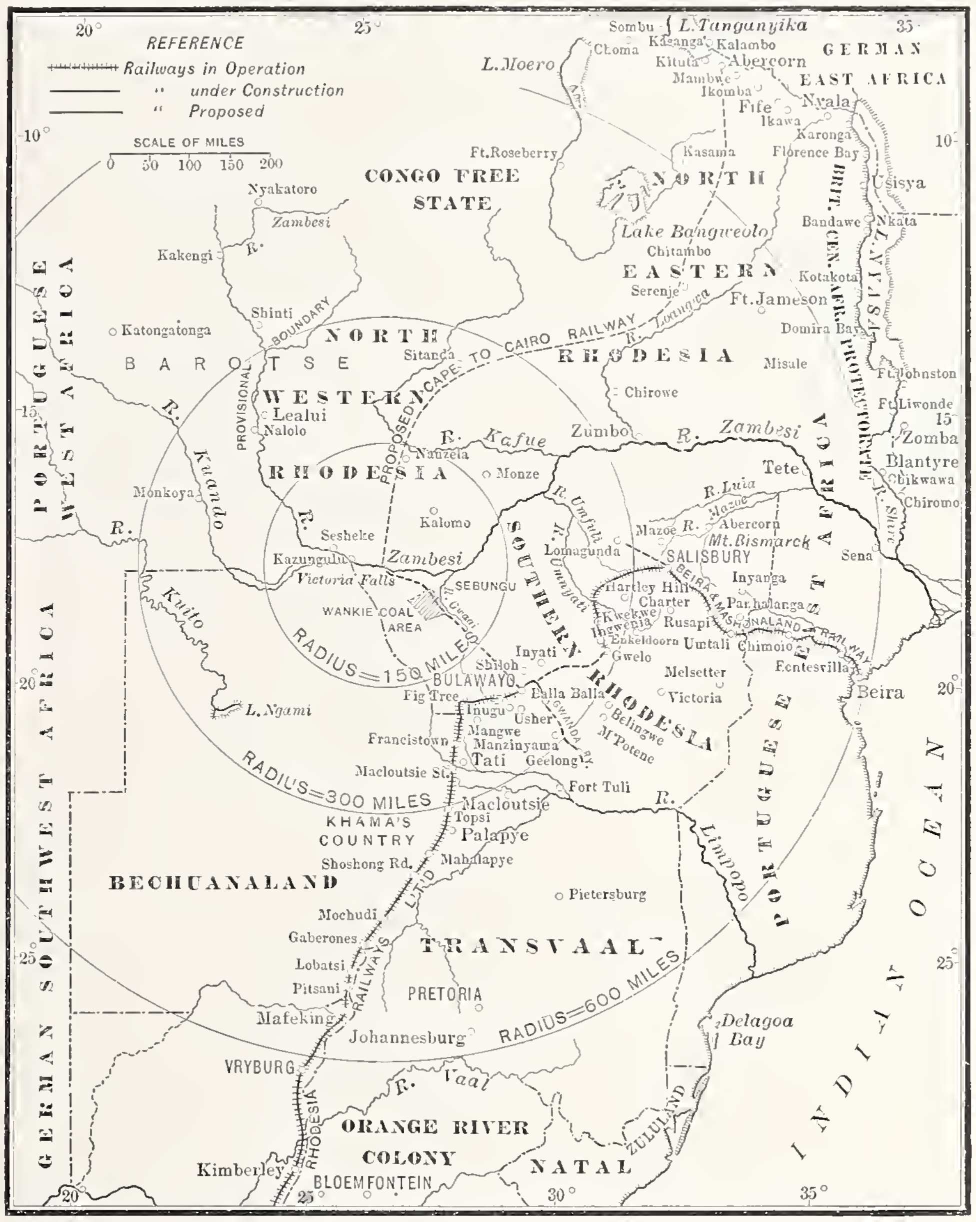
A well-known tunnel contractor in Scotland called upon the writer to ask if there were not some mistake in the above figures. Had not a decimal point been left out? He would consider 70 to 77 feet a month good work. He could not believe that ten times this rate of progress could be attained until the official returns were shown to him.

One objection has been raised to the introduction of this drill into the gold mines of Johannesburg, namely, the comparative scarcity of water; but as the water can be used over and over again, this objection is of small importance. This drill is actuated by high-pressure water,—1500 pounds to the inch,—and is kept up to its work with a pressure of 10 tons; all the waste water is discharged through the drill up to its cutting points, thus keeping it cool and washing out the débris. If pumps are required, they can be driven either by air or electric current, or, should the mine be of great depth, the hydrostatic head of water in the supply pipe would give the required pressure. The waste water would be collected in an underground tank and raised to the surface by electric pumps, and could thus be used over and over again.

In the case of the Chauvery Falls, in Mysore, India, an electric power installation has been provided to furnish power for the gold fields, and the current will be transmitted a distance of 93 miles.

The voltage at the generator is 2200 volts, and the line voltage is 30,000. Owing to the valley of the river being malarious, the switchboard is placed on high ground 1000 feet away from the power house. There are seven generators of 750 K. W. each, with revolving fields and stationary armatures. There are fifteen step-up transformers of 375 K. W. each, and fifteen step-down transformers each of 330 K. W.

The transmission line consists of two parallel lines of poles 60 feet

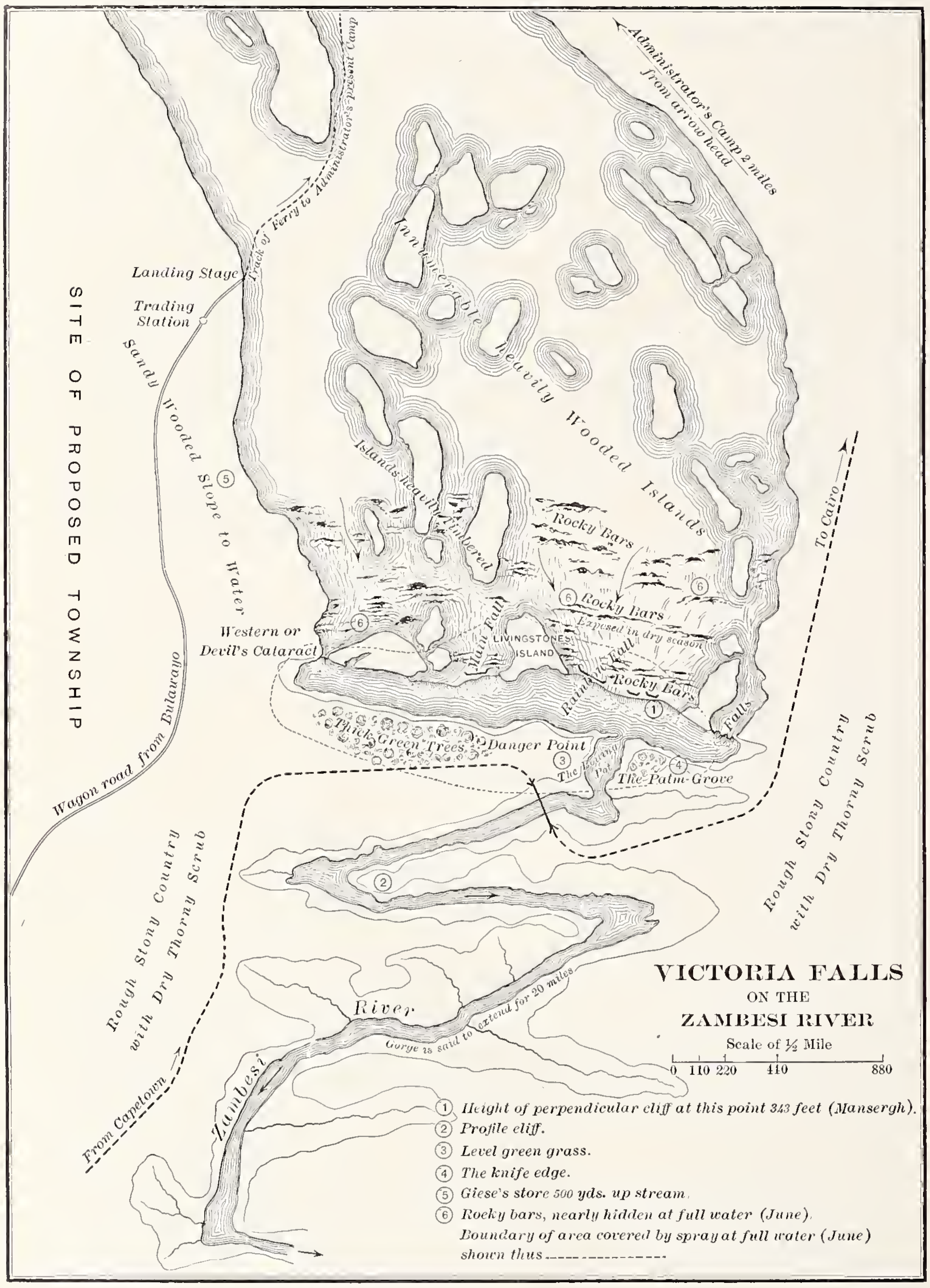


By permission of the British South Africa Co.

MAP OF RHODESIA, SOUTH AFRICA, WITH SPECIAL REFERENCE TO VICTORIA FALLS AND THE SURROUNDING AREAS LIKELY TO BE SUPPLIED WITH ELECTRIC POWER FROM THEM

apart. The poles consist of steel sockets 13 feet in height, which carry timber posts 17 feet in height and 7 inches square. Each pole carries three No. 0 B. & S. gauge bare copper wires, the insulators being arranged so as to form an equilateral triangle with 40-inch sides. The poles are approximately 130 feet apart along the line, but in at least one river crossing a span of 525 feet is required, and stranded silicon-bronze cable of high tensile strength is there used. Similar wire is used wherever railways or telegraph lines are crossed.

Some of the advantages of a double-pole line are, less likelihood of complete interruption of the circuit, due to the improbability of both lines giving out at the same time, and also the possibility of effecting repairs on one line while the other is delivering power.



The electrical transmission of the Missouri River Power Company, in the United States, is well worthy of notice. With an average head of water of 30 feet, about 10,000 H. P. are available. Machinery for about 4000 H. P. was, in the first instance, installed, consisting of four 750 K. W. 550-volt, two-phase generators. The current is raised from 550 volts to 10,000 volts, and sent to Helena, 20 miles from the power house, and East Helena, 14 miles distant, where it is stepped down for consumption. In 1900 six additional 750-KW generators were added for the purpose of supplying power to Butte, Montana, 65 miles away. The transmission line passes over the mountains at an altitude of 3300 feet above the power station, and consists of three lines of posts, 50 feet apart, the distance between the posts being 110 feet.

The wires are placed in the form of an equilateral triangle, each side being 78 inches long. The insulators are fixed on oak pins boiled in paraffine. The current, as already stated, is generated at 550 volts, but in this case is stepped up at the power house to 50,000. At Butte the step-down transformer reduces the voltage to 2200.

One of the most remarkable examples of electric long-distance transmission is in the State of Washington,—the Snoqualmie Falls plant. The transmission line is 44 miles long, carrying current at 30,000 volts, and in order to protect the generators from the spray of the falls the power house is a cavern cut out of the solid rock 250 feet below the surface, in which there are six generators of 1500 KW each.

The Bay Counties Power Company utilize the Yuba Falls, at Colgate, California, in a power house containing three units of 3000 H. P. and four of 1500 H. P., and deliver current at Oakland, 152 miles distant; thence it is passed along the transmission lines of the Standard Electric Company to San Francisco,—a further distance of 70 miles,—making 222 miles in all.

For nearly two years power has been delivered from Colgate to Stockton, a distance of 216 miles, and, during the month of August, 1902, in order to avoid a "shut-down" at Sacramento, 1000 KW were transmitted 270 miles, the longest distance yet attained. The volt meters at Sacramento did not show anything abnormal, nor did the operators there know anything as to whence this power was being derived until the operation was over.

The lines are all laid out for a 10 per cent. loss, transmitting 12,000 H. P. The voltage is at present 40,000, and is intended to be raised shortly to 50,000; but, in the opinion of the general superintendent of the line, Mr. L. M. Hancock, there is no reason why 60,000 to 80,000 volts should not be employed, if the line be properly designed, every insulator being tested up to 120,000 volts.

The latest results attained in America enable the following average percentages of efficiency and loss to be ascertained, assuming a power of 10,000 KW, or 13,400 H. P., delivered at a point 300 miles distant:—

	KW.
Step-down Transformers, 98 per cent. efficiency	10,200
Transmission Line, 70 per cent. efficiency	14,600
Step-up Transformers, 98 per cent. efficiency	14,900
Generators, 96 per cent efficiency	15,500
Water Turbines, 80 per cent. efficiency	19,400
Water Mains from falls, 90 per cent. efficiency	21,600

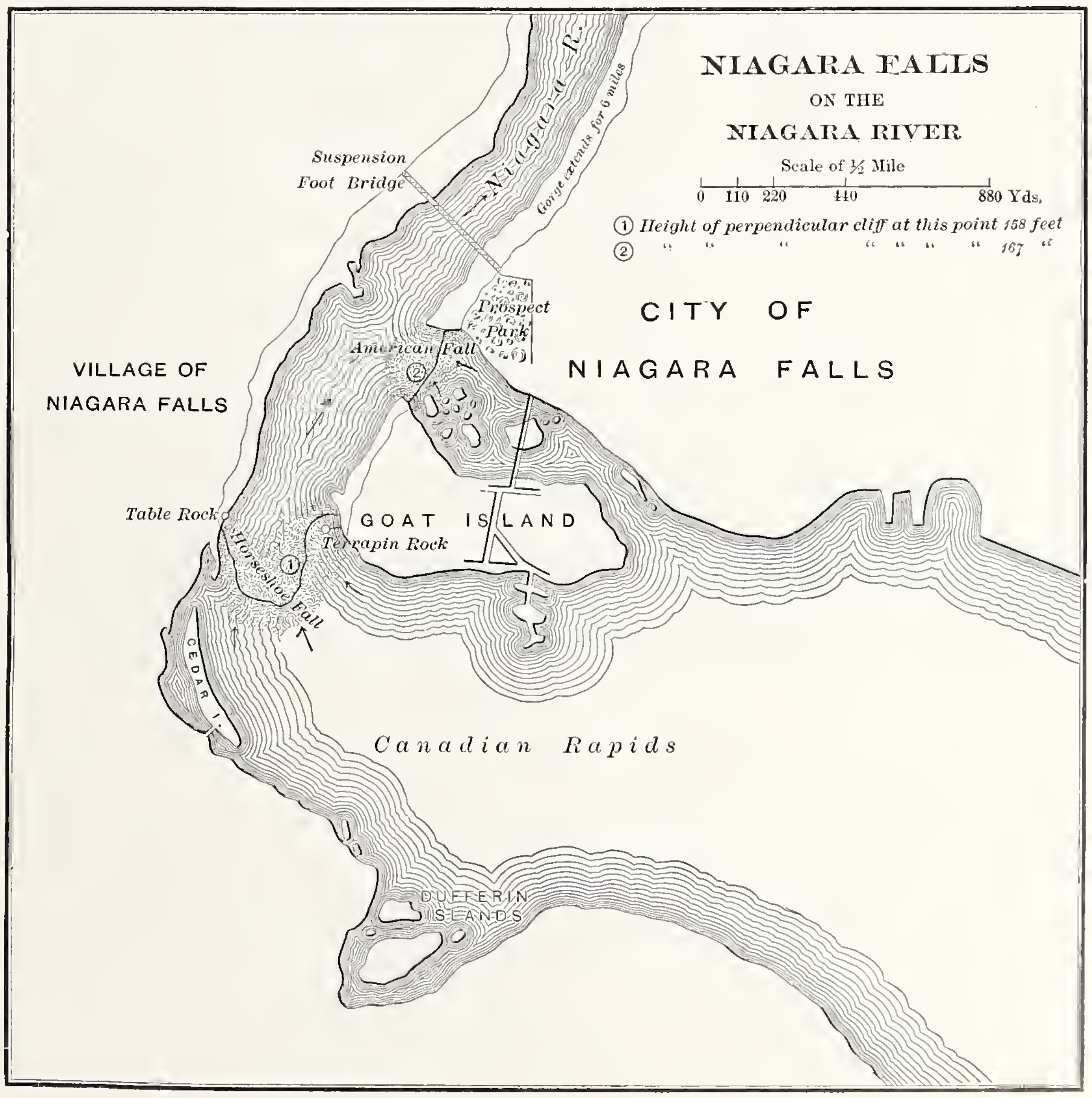
ANOTHER VIEW OF THE GORGE, ABOUT A MILE BELOW THE FALLS

Copyrighted by W. Rausch, Bulawayo

This represents a delivery to the consumer of 46 per cent. of the actual power of the water at the falls.

Having thus briefly reviewed what has been done in some other parts of the world in the way of utilizing water-power, we will now consider the question of possible electrical development from the Victoria Falls. In a new country, like Rhodesia, everything is required for what is practically a new country, and in connection with its extensive gold deposits there are two essentials, cyanide of potassium and quicksilver. Of both of these large quantities are requisite. Although quicksilver has thus far not been discovered in quantity, samples of cinnabar, from which it is obtained, have been brought in by the natives, and it is probable that both the above agents can be produced on the spot.

Gold mines to the southeast, the coal mines of Wankie, and the important copper deposits in Barotse Land, which are believed likely to prove among the greatest in the world, would all require power to a very large extent. Chemical and metallurgical industries will be attracted, as they have been at Niagara, and, if alluvial gold deposits exist, as reported, in the vicinity of the falls, they might be cheaply worked by "hydrau-



licking," that is, washing down the beds by powerful water jets supplied by electrically-driven pumps.

Water would also be required for irrigation, and plowing, sawing timber, and all kinds of agricultural work

ANOTHER VIEW OF THE FALLS

Copyrighted by W. Rausch, Bulawayo

could be carried on by electrically transmitted power. The great need for manufacturing on the spot all the various products which can be obtained by electrical energy is at once apparent when it is remembered that, at the present time, these have to be obtained from America and elsewhere, and transported thousands of miles, by sea and land, to the numerous points of consumption within a moderate distance of the Victoria Falls. In other words, both the necessary materials and the power are at the very doors of the Rhodesian population, and need only to be rightly developed.

The power house at the Zambesi would be placed on a benching in the second zigzag below the cascade, and would be supplied with water by steel tubes from the fall. Any amount of power required could be obtained, and an available head of at least 250 feet could be utilized. Each pipe or tube, 8 feet in diameter, would drive a turbine and generator necessary for 5000 horse power, and it would probably be found desirable to lay down the plant in units of this magnitude. The ultimate size of the power house would have to be determined by the demand for electricity in the neighborhood.

The question of voltage would depend much upon climatic conditions, and also upon the output and the distance to which power would have to be transmitted. At high voltages the air ceases to be a good insulator, and when moisture is present, sparking into the atmosphere takes place, and a large amount of electricity passes through the air from one wire to another. Transformers and insulators can be designed for much higher voltages than are now adopted, but at present the limit seems to be that at which an uncovered copper conductor will retain the current.

The rapid advance which is being made in electric transmission work enables distances to be satisfactorily dealt with which were considered impracticable four or five years ago. Many of the difficulties which were anticipated have never arisen, and many interesting and scientific observations have been made, such, for instance, as the tendency of high-tension current to keep porcelain and glass insulators dry in moist climates, and even during rain. It is only a question of conscientious work and careful design to make a long-distance transmission, even of 300 miles, within the near future a successful commercial undertaking.

Combination of Wireless Telegraph Companies

AT the annual meeting of the International Wireless Telegraph Company, held at Camden, N. J., on January 6th, a resolution to consolidate with the American DeForest Wireless Telegraph Company was adopted without a dissenting vote. The Greater New York Security Company will finance the consolidation. The International stockholders, it is said, will receive $7,500,000 of stock in the new concern and have an interest in about seventy patents. Vice-President and General Manager Gehring reported that instruments of the American DeForest Company had been ordered by the Belgium, Sweden and Japanese governments and that the London "Times" had two sets ordered in anticipation of war in the Far East. The following directors were elected: Dr. G. G. Gehring, H. Shoemaker, M. Van Boskirk, William J. Hopper and John Mayhew.

Electric Meters

Their Relation to the Earning Power of Electric Light Companies

By C. D. HASKINS

THE efficiency of generating apparatus and distributing devices and systems, the efficiency of engines, boilers, or other prime movers, and even the price of coal are relatively insignificant factors individually in the earning power of an electric light property as compared with the meters which are used upon the system.

The intelligent selection of the best meter for the conditions to be met, and the intelligent upkeep and supervision of these meters after their installation, in a large measure determine whether the illuminating property will or will not yield adequate earnings for the stockholders.

The average electric light system to-day delivers to its customers not less than 10 per cent. more energy than those customers pay for. This loss of 10 per cent. of the just revenue is due to three causes:—

1.—The continued prevalence of a certain considerable percentage of contract customers having no meters.

2.—The use of inefficient low-grade, or obsolete meters.

3.—The failure to test, inspect, and maintain the meters which are in service.

The assumption that a meter which, when just purchased, shows excellent accuracy from light load to full load, will remain and continue to show similar results in service is a fallacy. A recording meter is a low-powered and delicate piece of apparatus at best, and its accuracy will remain permanent almost in direct proportion to the relative amount of power or turning force which the meter possesses. It will be appreciated by all that a device having very little turning power may, nevertheless, run with perfect accuracy and freedom when entirely clean and unworn in any of its parts.

A meter to be permanently accurate must not only show good accuracy from a very light load, say 2 to 5 per cent. of its rated capacity, up to a reasonable overload, say 20 to 50 per cent. of its rated capacity, but must also under measurement show a high turning moment or torque.

As a general thing a fair idea of the relative torque or turning moment of a meter can be obtained by noting the number and sizes of drag magnets applied to the damping disc. The larger and more numerous these magnets are, generally speaking, the more considerable the torque; but this evidence cannot be relied upon wholly, because magnets vary widely in strength; consequently more positive means should be resorted to for measuring the torque.

A popular misconception has prevailed to the effect that there is advantage in using only one or two sizes of meter, the idea being that a less total number of meters will have to be purchased if only two or three sizes are used, since a smaller reserve stock will be required. The only economy achieved by this policy is the necessity of purchasing a somewhat less number of meters for stock. This may affect the expenditure of the company for meters to the extent of 5 or 10 per cent. But 5 or 10 per cent. of the annual expenditures of a lighting company for meters is a sum utterly insignificant as compared with a loss of even 1 per cent. on the revenue. As in the case of meters of low turning moment or torque, so, too, large meters may initially show remarkable accuracy on small loads; but the turning moment or torque of every known form of motor type, recording watt-hour meter decreases in direct proportion to the load. Consequently a meter which, for example, has a torque of 80 mm. gms. at full load, and is of 25 amperes capacity, will at one lamp ($\frac{1}{2}$ ampere) have a torque or turning moment of one-fiftieth of 80 mm. gms., or 1.6 mm. gms.

However well this meter may perform at this load when new, it cannot be expected to perform with equal accuracy after a year or two of use, as compared with a meter having 80 mm. gms. at full load and of a capacity of 10 amperes, because the 10-ampere meter at one lamp will have a torque of one-twentieth of 80, or 4 mm. gms. Hence, lighting companies should always use the smallest meters which they can use with safety. This may be detrimental to the immediate interests of manufacturing companies who secure somewhat higher prices and therefore larger gross sales in connection with the sale of large meters than small, but it is distinctly to the advantage of the illuminating company. It is better to carry 10 or 15 per cent. more meters in stock and to occasionally lose a meter from a burnout due to overload,—a very rare occurrence in modern meters,—than it is to put in meters larger than are required.

Illuminating companies should also be exceedingly careful in their investigation of meters which appear to have extreme overload capacities. For example, a meter having the best of accuracy at 100 per cent. overload may very fairly be considered as being a meter which is really rated lower than its actual size. If, for example, a meter is rated at 15 amperes and shows the best of accuracy at 30 amperes, it is debatable whether this meter should not in reality be rated at say 20 or 25 amperes. This means that the light load will suffer for the reasons given above.

The safest way in studying permanent accuracy in relation to light load is to reduce the calculation to mm. gms. torque at one-twentieth load, or 5 per cent. of the meter's rated capacity. Long experience has taught that sustained meter accuracy over a period of years cannot, and should not, be expected at loads of less than one-twentieth of a meter's rating. Below this, fair approximations only may be achieved, dependent upon the construction, and largely upon the torque of the meter. It may be said generally that loads on which a meter operates at less than, say, 3 mm. gms. torque will be loads upon which the meter will not permanently render the highest accuracy.

Thoughtful central station managements will readily appreciate from these statements the grave effect upon revenue which may result from a slight initial mistake in the selection of meters.

Up to this point only questions pertinent to non-inductive loads and the accuracy of the meter thereon have been dealt with. It must be remembered, however, that there are other conditions besides those already cited which must be accurately dealt

with by the meter. Inductive loads are common already and are becoming more so. Fortunately, the accuracy of a meter on inductive loads changes little if any in service. In other words, accuracy on inductive loads will remain practically unchanged in relation to the accuracy on non-inductive loads.

Meters not infrequently err initially on arc lamp and fan loads, and, therefore, no meter should be used by a central station which fails to show a high degree of accuracy under such conditions. Inductive devices frequently form a very large proportion of the whole load, especially during the summer months, and very serious impairments of revenue may result from the use of a meter which may be entirely accurate under non-inductive loads. In some cases under these conditions meters may operate too fast, leading to a dispute with the customer, a test and demonstration of excessive record, and a rebate extending back possibly for months and affecting bills which may very well have been recorded, not upon inductive loads, but upon non-inductive loads, thus resulting in a rebate many times in excess of the actual over record, and thus seriously impairing the gross revenue of the company.

Lighting companies should, furthermore, weigh with great care the question of using meters sealed prior to shipment. Meters which are sealed and which must be returned to the manufacturer for recalibration, repair or adjustment, menace the revenue of the company as well as its expenditures. They menace the revenue because the temptation to leave such meters in service long after they cease to record with high accuracy on light loads is almost irresistibly strong. No central station likes to remove a meter from the premises of a customer and install another. It increases expenses for labor and it shakes the confidence of the customer. Consequently, rather than take down a meter which is inaccurate and return it to the manufacturer for repairs, it is often left to operate month after month on a basis which loses to the illuminating company a considerable percentage of its just revenue.

Such a meter, when finally removed and returned to the manufacturer, even though it be repaired under a guarantee and therefore at no cost to the lighting company, must be out of stock for a considerable time, so that instead of becoming available for immediate reinstallation within forty-eight hours of the time of its removal, as it would be in case repairs were executed locally, it may be out of hand for weeks or even months, thus necessitating carrying a materially heavy stock in the local storeroom, although, as a matter of fact, the fault for which the meter was removed might in all probability have been repaired with ease and dispatch on the premises of the customer without removing the meter from the wall and without creating suspicion.

The wear of bearings in meters is the most common and prolific scource of revenue-impairing trouble incident to recording meters. It must be borne in mind that friction in a meter is inevitable and that that form of bearing which shows the least friction initially need by no means be, and seldom is, the best bearing for a long period. The most efficient form of bearing yet devised for recording meters consists of a cup-shaped jewel of sapphire as the stationary member and a pointed shaft end or pivot, the point of which should be of the hardest and toughest steel, possessing the highest polish and having a section of substantially a hemisphere.

Such bearings have in the past given a great amount of trouble when used in connection with meter mechanisms, which from principle or construction were obliged to carry rotating elements of extreme weight. Such bearings also have proved highly fallible when used in connection with meters of very low torque. In the first instance wear of the sapphire and pivot have resulted after a year or more of use, necessitating the renewal of both jewel and pivot. In the second instance in meters of low turning moment a general slowing up of the meter from friction results, at least in a considerable measure, from the accumulation of foreign matter in the jewel cup, which would be unimportant in connection with a meter of high torque, but which may materially reduce the speed of a device of low turning moment.

Side or lateral friction is likely to be more serious and detrimental than vertical pivot friction, since it is applied to a larger diameter of the moving part. Hence the accurate level of meters is of importance, and meters should be especially selected with a view to a maximum freedom from bearing surfaces making contact with the rotor laterally.

Much of success or failure depends upon the construction of that portion of the meter known as the recording train or dial. It is in this portion of the meter mechanism that friction frequently goes up in a rapid ratio, as the age of the meter increases. This is due to dirt, wear, and bad construction. A badly cut or rough worm not infrequently cuts and destroys the shape of the teeth of the worm wheel, in some cases multiplying the friction between worm wheel and worm by a large amount. The use of iron pinions with resulting rust is a prevalent cause of trouble, and it must be always remembered that substantially no recording train can be run all of the way around on all wheels to prove the accuracy of cutting of the pinions and teeth. Consequently, unless recording trains are cut and finished with the utmost nicety and care, great friction may suddenly develop after the meter has run several million revolutions, because even at this point the last or highest wheel will not have made a complete revolution, and may at any time present an imperfect tooth with consequent evil results. The worm, pivot, and wheel construction of recording mechanisms should be the subject of special analytical examination.

In connection with recording train difficulties the importance of high turning moment or torque will be appreciated. The check due to an imperfect tooth in a recording dial is severe, but temporary, and a meter having a high turning moment may very well run over and past an imperfect tooth which would stop a meter of lower power. This is true, whether the temporary check be due to the imperfect wheel, or to dirt, or rust, or other friction producer.

The effect of external temperatures upon meters should be watched with the greatest care. Almost all central station systems have a large number of meters installed at points where they are exposed to changes of temperature ranging from almost zero degrees F. to 100 degrees F. In numerous instances these changes of temperature may affect the revenue of the company.

As a last word of warning, it should be remembered that meters rarely err by over-record. Ninety-nine times out of one hundred such errors as occur are errors slow. Substantially every meter in service under-records at some load, and the accumulation of such errors throughout an entire system is always an increasing factor, save in the face of constant vigilance.

The lost revenue which could be saved with the meter art as it now stands might well suffice to pay dividends on the common stock of many corporations which to-day pay none, and yet leave a sufficiently large surplus to create a substantial annual sinking fund.

Electric Shocks

By ARCHIBALD WILSON

TIME was when the mention of electric shocks suggested merely the sensations experienced in grasping the handles of the ordinary induction coil, or in receiving the discharge of a Leyden jar. There are few persons who have not allowed an electric current to be passed through them by one or the other of the above means, and the sensations need scarcely be described. While the effect is usually of a mild and harmless nature, it is well known that shocks of an unpleasant character, and even dangerous to human life, may be applied even by such simple apparatus.

With the widespread adoption of electricity for domestic and industrial uses there have appeared occasionally in the public press notices of accidents due to electric shocks, sometimes attended with fatal results. Fortunately such accidents are infrequent, but the fact that they have occurred at all accounts for the question so often raised as to whether the employment of electricity is accompanied by risk to human life. The object of this article is to allay any apprehensions on the subject, and to point out the extremely improbable conditions under which accidental contact with electric wires can result in dangerous shock.

As the fact that an electric shock has been received by anyone implies that current has passed through a portion of the body, it may be well first to explain briefly the fundamental law which governs the flow of an electric current through any substance. This is known as Ohm's law, named after the eminent physicist who first enunciated it, and is of first importance to all who are even slightly interested in electrical matters. It may be briefly stated as follows:—The number of amperes (or amount of current) flowing along a circuit is equal to the number of volts (or electrical pressure) which is applied at the ends of the circuit, divided by the number of ohms of resistance in the circuit. By circuit is meant any path along which the current is flowing, and it may consist of a copper wire, the human body or any other substance capable of conducting electricity.

Resistance is the quality possessed by every substance, in a greater or lesser degree, of impeding the flow of current through it, and is somewhat analogous to mechanical friction. Just as friction makes it difficult to drag a heavy weight over rough ground, so does the electrical resistance of a body oppose the passage of a current, and in both cases heat is evolved as the result of the work done. From Ohm's law, accordingly, can be calculated by simple division the amount of current flowing through any body, provided the pressure and the resistance of a body are known.

Take, for example, the case of a person touching with the points of the forefingers two electric lighting wires with a pressure of 50 volts between them. The resistance from finger tip to finger tip would probably be about 50,000 ohms. Dividing the number of volts by the number of ohms, and it is found that the current would be one one-thousandth of an ampere, or, as it is technically termed, one milli-ampere. With a pressure of 100 volts, the current would be double, or equal to two milli-amperes; with 200 volts, four milli-amperes, while with double the resistance the current would be correspondingly halved. In other words, the greater the pressure, the greater will be the current, while the greater the resistance of the circuit so will the current be less.

A clear understanding of this simple law will enable the reader to appreciate more fully how the effect of electric shocks varies with the pressure at which current is supplied, and also with the resistance offered by the body. It will be readily understood from what has been said that the sensations of shock are more easily experienced with high than with low pressures, while if the resistance of the body be abnormally low shocks will be felt which, under ordinary conditions, would be imperceptible.

Electricity is best known to the general public in connection with its applications to telegraphy, telephony, lighting, motor driving, and street railway work. Of these the first two will not be considered, as the currents employed are slight and the risk of shock is practically negligible. In the case of the other applications comparatively high pressures and heavy currents are employed, and as the wires along which the currents are conducted have to be introduced into dwelling houses and factories, and, for street railway work, suspended over the thoroughfares, the question as to the possibility of receiving shock from contact with them is naturally one of common interest.

In the early days of electric lighting the pressure employed for interior illumination was generally limited to about 100 volts. At present, however, the pressure is usually higher,—seldom less than 200, but not exceeding 250 volts. If, as is generally the case in municipal lighting, what is known as the "three-wire" system of distributing current from the central station is employed, the current is actually generated at double the pressure used at the lamps. As the name implies, three wires are employed to form the main conductors between the station and the buildings to be illuminated. Two of these wires are called the "outers," and have the full pressure of, it may be, 500 volts between them. The third or "middle" wire forms, as it were, an intermediate stage in the range of pressure, so that between it and either of the two "outers" there is maintained a pressure of 250 volts. In lighting from these supply mains, one of the outers and the middle wire are led into the building and there suitably connected to the wiring system by which current is conveyed to the lamps.

The details of an ordinary house installation need not be here described. It is sufficient to point out that all wires employed are first covered with India rubber or other suitable insulating material so that there may be no leakage of current from them. They are then laid, for the purpose of protection from mechanical injury as well as for the sake of appearance, in grooved wood casing or in special conduits. At all points where the wires issue from the casings for the attachment of fittings or switches the metal parts to which they are attached are covered up, so that at first sight it would appear that bodily contact with the wires could not be accidentally made.

If both wires of the installation were thoroughly insulated, it would be possible to receive a shock only by touching both of them simultaneous-

ly. In most three-wire systems, however, the "middle" wire is connected to earth, which is a comparatively good conductor. In consequence the pressure between earth and either of the outers is the same as between the middle wire and the outer. A person standing on moist ground, or in any similar position which puts him in good contact with the earth, and touching a wire connected with one of the outers, would allow current to pass through him from the point of contact to earth. If his contact with the earth were bad and the resistance consequently high, the current might be so small as to be inappreciable. This is found to be the case in ordinary dwelling houses where the dry floors and carpets are of sufficiently high resistance to prevent any perceptible current from flowing to earth.

If the resistance were low, as might be the case in damp cellars, or if the floors were constructed of metal work, the current would be of greater amount and would probably give an unpleasant shock. So long as the insulation and protection of the wires and fittings remain perfect accidental shock in this way is impossible. Occasion, however, may, and sometimes does, arise when the insulation becomes imperfect. When that occurs and the wires are enclosed in wood casing, which in its normally dry condition is a fairly good insulator, there is small likelihood of shocks being inflicted. When, however, they are enclosed in metallic tubing, it is quite possible that the insulation of one of the wires might be damaged, and the wire itself might in consequence come in contact with the pipe.

If suitable precautions were not taken, the result would be that anyone standing in contact with a good earth and touching the pipe, which would be at the same pressure as the wire whose insulation was defective, would receive a shock. This risk can be totally obviated by connecting the system of pipe work to earth. When that is done, and in all installations where piping is used it ought to be done, then if there is accidental contact between the piping and the wire which is connected to the outer side of the system, so large a current would flow across the point of contact that the safety fuses with which all electric light installations are provided would immediately act and automatically cut off the supply. The risk of shock would thus be removed almost as soon as it had arisen.

It follows, therefore, that in such a lighting system it is possible to receive an accidental shock only if four conditions are simultaneously fulfilled. First, there must be metallic connection between one of the wires and the pipe in which it is enclosed; second, the individual must be touching that section of the piping; third, another part of the individual must be in connection with the earth through a path of low resistance; and fourth, the pipe itself must not be connected to earth. It is unlikely that the first three conditions would all be complied with at the same time; but in any case the omission of the fourth, by the systematic earthing of the piping, would totally obviate all risk of shock.

It is the usual custom to earth the piping at one or two convenient points only, by means of a copper wire soldered or bolted to water pipes or other metallic earth connection. Then, by fitting up the piping in one complete system without a break in its continuity no section of it can become "live" by contact with the wires without the supply being promptly cut off.

A shock from accidental contact with wires at pressures up to 250 volts under ordinary conditions, although unpleasant to most persons, is usually harmless. Conditions must be abnormal to render shock at these low pressures dangerous. While the general public have little experience of the subject, the receipt of shocks is an every-day occurrence with men engaged in electrical work, and is regarded with comparative indifference.

When electricity is employed for motor driving the pressure used is frequently as high as 500 volts, and with three-wire systems the motor, if not of very small size, is connected to the two outers. In this case, again, the earthing of all pipework is of vital importance, as is also the careful enclosing of all parts which are connected with the supply wires. Contact with either of the wires and a good earth will produce shock at 250 volts, and contact with both wires will apply the full pressure of 500 volts. As shock at the latter pressure is decidedly unpleasant even to the most hardened electrician, stricter precautions should be taken to insure that the work has been properly executed.

In electric street railway working the standard pressure is usually 500 volts, and current is supplied to the cars through a bare copper wire supported on insulators and stretched overhead along the routes. Only one wire is employed, and the current is returned to the supply station by means of the rails. In this class of work risk of shock may arise in two ways. Telegraph or telephone wires crossing the route of the railway may fall into the street, and in their fall may become "live" through contact with the trolley wire; or the trolley wire may break away from its supports and fall to the ground. Both contingencies are so well provided against that injuries from shock are of very rare occurrence.

As a protection from fallen telephone wires there is sometimes stretched parallel to the trolley wire, and a short distance above it, a galvanized steel wire. This guard wire is earthed at frequent intervals; the result is that a fallen telephone wire is either held altogether clear of the trolley wire, or should it come in contact with it, the current from the trolley wire, passing through the telephone and guard wires to earth, is so excessive that the safety fuses or other automatic devices are put into action and cut off the supply from the section in which the accident has occurred. Should the trolley wire break, the current can be cut off by section switches fitted for the purpose along the route, and in many electric railway systems the cars are provided with emergency switches by which the driver, in the event of a wire breaking, can connect the system to earth, and so cut off the supply through the action of the safety devices.

In the case of the very high pressures used in long-distance transmission of electric power, the mains in such systems are generally, within city limits, placed underground, and the current is transformed to low pressures before being introduced into buildings for lighting or motor driving. Such accidents as have occurred with high-pressure systems have, with few exceptions, been confined to the operatives employed in their working.

With continuous currents the sensations to which shocks give rise are, generally speaking, in proportion to the amount of current which passes; but they depend also on the extent of surface of the body on which contact has been made. Thus a current, barely perceptible if the whole surface of the hand be used to make contact, might be quite unpleasant if passed through the finger tips. Susceptibility of persons to shock varies considerably with the individual, apparently on account of variations in the hardness and moistness of the skin, the resistance of which forms a large proportion of the total resistance of the body.

In recent measurements of several individuals the resistance from forefinger to forefinger ranged from 70,000 to 25,000 ohms; when the points of contact were moistened with saliva these figures were reduced to 40,000 and 15,000, respectively. The same

individuals were made to stand on a wet iron rail, which was intended to represent a good earth connection, while a piece of copper about the size of an ordinary trolley wire was grasped in one hand well moistened. Here the resistances were found to vary from 8000 ohms to 3000 ohms, depending partly on the individual under test, and also to some extent on the thickness and wetness of the boots which were worn.

The sensations from shocks at various voltages can be learned only from experience. The writer, who, it should be noted, is not particularly sensitive to shock, can feel nothing when touching two wires at 100 volts pressure unless the fingers are moistened; then a slight prickling sensation is felt. Touching a 200-volt circuit with dry fingers gives a sharp tingle and a sensation of burning; at 400 volts the effect is unbearable. More sensitive persons, however, find the shock from 100 volts extremely discomposing, and although no danger may be incurred, it is inadvisable, unless one is thoroughly versed in the subject, to submit deliberately to shock even at that comparatively low pressure.

Cases of fatal shock are, fortunately, of rare occurrence, and are mostly confined to those employed in the generation and distribution of electricity. As can be readily understood, it is difficult to ascertain the minimum strength of current which is dangerous to life, as there is so much variation in the effect according to the circumstances attending the shock. Currents of 30 to 40 milli-amperes are probably as much as can be borne without great discomfort, although we find it stated that for medical purposes, and, of course, with due precautions, as many as 200 milli-amperes can be safely passed through the human body. The effect is, however, modified so much by the state of health of the individual, by the length of time during which shock has been inflicted, and by the path which the current has taken through the body, that no definite safe limit can be positively laid down.

As a general rule, the resistance of the human body is normally so high that with pressure not exceeding 500 volts accidental contacts are rarely fatal shocks, although occasionally the portions of the body on which contact is made are severely burnt. The few fatal accidents which have occurred at low pressures appear to have been attended by a body resistance far below that usually met with. The effect of a shock may also be to cause such muscular contractions that the victim is unable to let go of the conductor which he has grasped, and, if help is not at hand, death may result from the prolonged application of a current which, if it had been only momentary, might have been comparatively harmless. On the other hand, there are on record cases of shock at pressures of several thousands of volts in which death has not resulted.

The ultimate cause of death, when due primarily to electric shock, is generally considered to be stoppage of the action of the heart or of the respiratory organs. That the latter may be affected is shown by the fact that victims of electric shock are sometimes brought to by the practice of some of the well-known methods of artificial respiration. The cessation of the heart's action may be due to stimulation of the nerves which control the beating of the heart; these, when stimulated to excess, may cause the heart to stop altogether.

The reports which appeared not long ago in the newspapers of an accident resulting in death from shock which occurred at some public baths, attracted considerable attention, and were calculated to prejudice the public against electric lighting. The facts of the case were as follows:—The baths were enclosed in cubicles, divided from one another by slate partitions which were held in position by an iron framework attached to the upper edges of the slate. The wires for the lighting of the baths were contained in metal tubing which rested on this iron framing. On the evening of the accident the attendant heard a cry, and on entering one of the cubicles discovered its occupant standing in the bath with his hands grasping the iron framework on the top of the partition. The current was switched off as soon as possible, but the man had become insensible and never recovered consciousness.

Shortly after, when the other cubicles were examined, a second man was found unconscious, and in his case also death ensued. At the coroner's inquest it was shown that alternating current was used with a pressure of 200 volts. The pipe system was earthed at one or more points; but, owing to a break in the continuity of the pipe, that section of the pipe where the accident had taken place was not connected to earth. A faulty wire had made contact with this pipe, so that both the pipe and the ironwork on which it rested were "live" at a pressure of 200 volts from earth, while both were insulated from earth by the slate on which they were supported.

The bath was fitted with a metal waste pipe which served as a very efficient earth connection, with the result that from the man's hands, on the iron framework, to his feet immersed in water and resting on or near the waste pipe, there was provided a path of low resistance for the passage of current through his body. The resistance was probably much lowered by the presence of soda in the bath, by the large surface of the body exposed to the water, and by the moist state of the hands and of the ironwork. The resistance of the writer when tested under conditions approximately the same, namely, while standing in a bath of soapy water about 8 inches deep and with both hands grasping a piece of iron pipe, measured about 1000 ohms. This, as compared with the other measurements cited, is extremely low, and would, with a pressure of 200 volts, result in a current of 200 milli-amperes flowing through the body.

The lapse of time before the current was switched off no doubt contributed to the fatal result, while medical evidence showed that the action of the heart in one of the victims was probably weakened owing to the presence in the stomach of a large quantity of undigested food. It is probable that both men were in a very susceptible condition, for several bathers stated at the inquest that, by grasping the ironwork on the partitions, they also had received shocks, but without injurious results.

The obvious moral to be drawn from this incident is the importance of thoroughly earthing the entire system of piping. Had this been properly done in the above-mentioned bath installation, the accident could not have occurred. Perfect safety can easily be secured by insisting on a high standard of workmanship.

Although the dangers of electric shock have, of necessity, been referred to at some length, it must on no account be taken for granted that accidents are of frequent occurrence. As a matter of fact, considering the enormous extent to which electricity is employed, they are extremely rare and have caused relatively little loss of life.

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Contents

Beginning with this issue THE ELECTRICAL AGE, having been purchased by Mr. Louis Cassier, will appear under new management; but with the scant time at disposal it was impossible to make the January number in any sense representative of what the publication will henceforth be. A better measure of its future character will be afforded by the February issue, concerning which an announcement appears on another page.

Wireless Telegraph Developments

IT is now three years since we were promised in no qualified terms transatlantic wireless telegraphy. At intervals that may be said to have corresponded more or less with marked depression in the wireless stock market these promises have been repeated with increased emphasis; and in full page advertisements the public has, among other things, been informed as to the exact prospective earning capacity of each transatlantic wireless circuit, which earnings never fail to show a clear 10 per cent. profit annually on the entire capital stock of the company. These earnings, be it pointed out, are based on the possible earnings of a circuit working every hour of the year at a rate about equal to the best speed of the Atlantic cables, which is assuming a maximum of business to be handled which the Atlantic cables have not yet found forthcoming. Probably these cables are not operated to their full capacity more than five-sixths of the time, exclusive of Sundays.

The comparison is also made with the cable service as if transatlantic wireless telegraphy were an accomplished fact, whereas not only is this not so, but there is probably not at present a single wireless telegraph circuit in any part of the world where the business offered for transmission is sufficient to keep it occupied every hour of the twenty-four at the rate of speed mentioned, nor is it likely that there is in operation to-day anywhere a system of wireless telegraphy that can be relied on to work without interruption twenty-four hours of the day,—all of which is said without desiring to detract in the slightest degree from the immense importance of wireless telegraphy in its proper sphere.

But the foregoing facts profiteth the advertising and press agents of wireless telegraphy nothing. Their business is to facilitate the transmission of stock to the pockets of prospective investors, and indeed,—we trust the remark will not be considered unkind,—this appears to be the part of the business now being most energetically carried on by many of the promoters of wireless telegraphy.

The rein which some of these gentlemen give to their imagination is well exemplified in one instance where an installation consisting of a flag pole, a wooden building of the dimensions of an automobile shed, containing a small oil engine, a dynamo machine and the other ordinary apparatus of a wireless outfit, are alluded to as "a magnificent station" at Blanktown. When, however, the short time that has elapsed since wireless telegraphy was introduced as a new art is considered, one wonders not so much that transatlantic wireless telegraphy is not yet an assured practical success, but that the art has already attained a degree of practicability whereby it is possible to communicate between passing vessels, and vessels and the shore, with fair regularity and precision.

For these results unstinted credit should be given to the inventors of the various systems; and it is, perhaps, quite possible that if these inventors were allowed to pursue their preliminary investigations and experiments to a conclusion without undue pressure to show immediate practical results of some kind, the actual progress would have been even greater than it has been. Sooner or later the possibilities and limitations of this art will be better understood, at which time it will be assigned to the work for which it is pre-eminently adapted, and the brain-wearing attempts to show its adaptability to purposes which are already better performed by other methods will be abandoned.

Making Gold from Silver Electrically

THE electric theory of matter has received a strong impetus at the hands of Lodge, Thomson, Crookes and others, especially since the discovery of the radioactive substances, such as thorium, radium and others. This theory assumes that the material atom is made up of a large number of so-

called electrons, the number depending on the density of the substance. Thus, for instance, it is assumed that an atom of hydrogen is made up of about 700 electrons, a mercury atom of about 140,000 electrons, and a gold atom of about 137,200. The different known elements, therefore, are made up of different groupings of electrons. The theory further assumes that these electrons are in stable orbital rotation around one another, the whole being held together by mutual attraction, their orbits being as large relative to the size of the electrons as the orbits of the planets of the solar system. With such a theory as this it was to be expected that modern alchemists would promptly seize the opportunity of bringing about a rearrangement of the electrons so as to produce from one element a more valuable one.

This expectation has been realized in the person of a Philadelphian inventor or experimentalist who claims to have already brought about a transmutation of silver into gold. He selects silver for the transmutation because of the approximate similarity of these two elements chemically considered. The process by which the transmutation is accomplished is chemical and electrical, of course. The inventor admits that the elementary forces of nature in combination and decomposition are well-nigh irresistible, and, therefore, to transform one atom into another it is necessary to destroy the inductional capacity of the electrons by bringing them to a condition of temporary inactivity or torpor. The electrons can then be segregated, he claims, and forced out of their previous correlation, and then be reassembled in any desired grouping. The inventor has no difficulty in showing prospective investors in the stock of the company which will probably be organized that the net profits in transforming one million ounces of silver into a similar amount of gold will be over sixteen millions of dollars, the cost of transformation being only 17 per cent. of the value of the product. This scheme, it will be seen, is quite as reasonable as, and far outstrips in calculable profits, the Keeley motor enterprise, the home of which, by the way, was also in Philadelphia.

High-Pressure Gas Distribution by Gas Power

A GAS-POWER installation of exceptional interest is now under construction by the Laclede Gas Light Company, of St. Louis, Mo. The system has for its object more efficient distribution of gas over large areas than may be economically covered by the simple method of running large low-pressure mains from a centrally located gas-generating plant to supply all parts of the city. The system under construction is intended to supply the entire city of St. Louis, embracing an area of approximately 65 square miles.

It is evident that in order to serve the outlying districts of such an area, one of three methods must be employed—first, large low-pressure feeder from the central holder to center of district to be covered; second, medium-sized feeders from main holder to auxiliary holder in center of district; and, third, high-pressure feeder to distributing center, using pressure-reducing valves at this point for obtaining proper pressure upon the service lines. The enormous expense for construction entailed by the first two methods has practically prohibited their use in St. Louis, and the high-pressure system is being installed. With this system, the size of feeder pipes is greatly reduced, and the necessity of auxiliary district holders is entirely done away with.

For serving suburban communities, lying far beyond the city limits, this method may be extended and the pressure of the gas raised to any desirable extent for transmission through small pipes, this pressure being reduced at the suburban distributing center by pressure regulators, as in the medium-pressure system above mentioned.

This gas-distributing system as a whole presents a striking similarity to the ordinary alternating-current distribution system with primary high-pressure feeders, reducing transformers and secondary low-pressure distributing lines, the theory of high-pressure transmission being in both cases identical.

The pressures to be employed in the system under construction at St. Louis are approximately 5 lbs. per square inch for the medium-pressure feeders, and from 20 to 80 lbs. per square inch for the high-pressure suburban feeders. On account of the use of cast iron mains, the 5-lb. limit was chosen for the medium-pressure system, but for the high-pressure system iron pipes with screwed fittings will be used. With this construction any desirable pressure may be carried with entire safety and the radius of distribution extended to 100 miles if necessary.

In the medium-pressure system the gas pressure will be supplied by a blowing unit, consisting of a standard Connersville blower direct-driven by a 300-H. P. Westinghouse horizontal gas engine. The engine is of the type recently brought out for high-power work and embodies a number of newly-developed features which distinguish the construction of the horizontal type. The engine has two double-acting cylinders, $16\frac{1}{2}$ inches in diameter and 24-stroke, arranged in tandem fashion, with a single crank. The engine uses for fuel the ordinary illuminating gas, such as is distributed to customers, and draws its supply directly from the gas main.

The St. Louis installation is one of the first of its kind in the illuminating gas field, although the system has long been in successful use in the distribution of natural gas over large districts adjacent to natural gas fields. The St. Louis system is in charge of Mr. W. A. Baehr, engineer of the Laclede Gas Light Company.

The Harmlessness of Electricity

WHEN fatalities or damages seemingly attributable to electricity occur, the popular belief is that electricity itself, as a force, is directly responsible for them. In fact, however, there are few forces of nature that are less harmful in themselves than electricity. The damage done by flood or tornado, for instance, is done directly by the water or the air. But electricity, when it works, usually does so indirectly or by setting another of nature's forces into operation.

An exception to this may be where the victim may have been so weak, physiologically, that a simple fall from a chair might have had a similar result. But in the majority of cases death from electric shock is shown to be due to well-defined chemical changes in the blood or tissues, due to the electric current. The damage done also to gas and water pipes by electrolysis, whilst primarily occasioned, it is true, by the escape of electricity from electric railway circuits, is not directly due to that force, but rather to a secondary action, and that a purely chemical one, namely, the setting free by electrical action of certain elements, such as chlorine and sodium, constituents of a saline solution in the soil, which attack and corrode the iron pipes. Without some such solution in the soil there would be no such thing as electrolysis. Also, when lightning strikes a tree and shatters it, the result is not due directly to electricity, and not even to the electric current, but rather to the intense heat which the electric current generates in passing through the tree, which heat suddenly converts the sap into steam, and the latter in expanding, if the force be sufficient, tears the tree to pieces. If the force is not sufficiently powerful,

the effect may be only to loosen the bark of the tree in places, the evidence of which may last for years, but may not be otherwise hurtful to the tree's growth. So far, indeed, from electricity being necessarily fatal to animal or vegetable life, it is well known that in proper quantities it is decidedly beneficial, and, when properly applied, acts as a stimulus to vegetation. An excess of current, however, will also kill vegetation. In both of these cases its action is due to the chemical changes which it effects in the growing plant or tree.

The injuries to shade trees by contact with wires carrying heavy currents, such as electric light or traction wires, is mostly mechanical, an arc forming at the point of contact of the wire with the branch or limb and burning away the wood, leaving the tree stunted at such places. In very stormy, wet weather, it is not uncommon to have large trees set on fire by the escape of current from abutting electric light wires, the rain, paradoxical as it may seem, by improving the conductivity of the circuit down the tree to the earth, virtually adding fuel to the flames.

The Present Status of the Joint Engineering Building Plan

In regard to the work which has been done on the joint Engineering Building, for the erection of which Andrew Carnegie will give $1,000,000 and upward, by the committee of fifteen, an interesting circular has been issued by the American Society of American Engineers. It embodies a good deal of new material and data, part of which, the report of the committee on organization, composed of Dr. A. R. Ledoux, C. W. Hunt and Dr. S. S. Wheeler, we give below:

Having considered legal advice and taken note of all suggestions received, the committee unanimously advise as follows:

1. The total amount offered by Mr. Carnegie shall be administered as two gifts: one to the engineering societies, and the other to the Engineers' Club, each to be held and administered independent of the other. The allocation of the fund to be made at once, but the buildings to be designed and erected as one operation; thereafter the respective titles and administrations to be entirely independent.

2. The property represented by land, buildings and equipment of the engineering societies, shall be held and administered by an executive corporate body, preferably under a special charter, to be obtained from the State of New York, each of the constituent societies being entitled to name from its membership three persons to act as incorporators and thereafter as directors.

3. Each society annually to elect or appoint, as their by-laws may prescribe, one of their voting members to serve on the board of directors of the executive corporation for a term of three years; a vacancy in said board to be filled by an appointment made by the society the retirement of whose representative causes the vacancy.

4. The land and property being held for the societies by an executive corporation, the said corporation may, to pay for the land acquired, issue certificates of indebtedness or bonds bearing interest at 4 per cent, and redeemable on six months' notice, the buildings being a gift from Mr. Carnegie.

5. Each of the constituent societies may purchase and hold an equal amount in value of the said bonds or certificates, but the board of directors of the executive corporation may authorize any of the constituent societies to hold an additional amount; that is, in excess of its portion, but such excess shall be subject to recall at its par value at any time that the directors of the executive corporation may so order, to the end that each society shall have an equal interest in the property of the corporation if it so desires.

The certificates held by each society shall be inalienable unless they are offered to the executive corporation at their par value, and such tender shall not be accepted by the board of directors within one year thereafter.

6. The property of the executive corporation shall be used perpetually as a meeting place and headquarters for the constituent societies, and for such other scientific associations as may be temporarily admitted by the consent of the board of directors of the executive corporation. Such associations may pay a pro rata share in the expenses of the headquarters, but no profit shall be made for such use.

7. Each of the participating societies shall be entitled to rooms and space in the property adequate to its need, paying its share of the running expenses in accordance with the amount of space occupied; said space to be assigned and a proper assessment therefor determined by the board of directors of the executive corporation.

8. The excess of receipts over expenditures, if any, shall be used for reducing the subsequent contribution of the several societies for maintaining the bulding, and for the advancing of engineering arts and science, by and through the participating constituent associations. No dividends shall be declared or profits divided, but a reasonable repair and rebuilding fund may be established.

9. If the income of the executive corporation shall be less than the expenditure, the deficiency shall be made good by an assessment on each of the constituent societies, so allocated as to be in proportion to the number of voting members of each society.

An excess of receipts over expenditures may be allocated to the societies in like manner to reduce their annual assessment.

10. Should any of the constituent societies fail or refuse to appoint directors, the remaining members of the board of the executive corporation shall administer the property with all the force and effect as though the board contained its full quota of members.

11. Finally your committee, in offering the above suggestions, has had in mind the setting aside of the money used for a building for the Engineers' Club, so that on the completion of the said buildings the relations of the club and of the engineering societies will terminate. Thenceforward, the constituent societies are to carry through the executive corporation the administration of the building and its accessories, leaving the scientific, professional, intellectual and financial activity in each organization entirely independent of the others, and free to develop to any extent and along any line that may be determined each for itself.

The Morse thermo gauge, by means of which one can tell at a glance how hot a mass of metal is, consists of a short telescope tube containing an incandescent electric lamp, having its filament arranged in spiral form. This is connected to an ammeter and rheostat, by means of which any desired current may be switched on the lamp. A table gives the heat equivalent of various degrees of incandescence. When current is on the lamp and the instrument pointed at the heated object, the spiral will appear brighter or darker than the object viewed, according to the amount of current in the lamp. The rheostat is set to the proper current to give the desired heat in the metal, say 900 degrees. When the filament shows no brighter or darker than the metal the object has reached the 900 degrees. The instrument is said to be very accurate, not varying 5 degrees in 1,000.

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The Cooper Hewitt Mercury Vapor Lamp

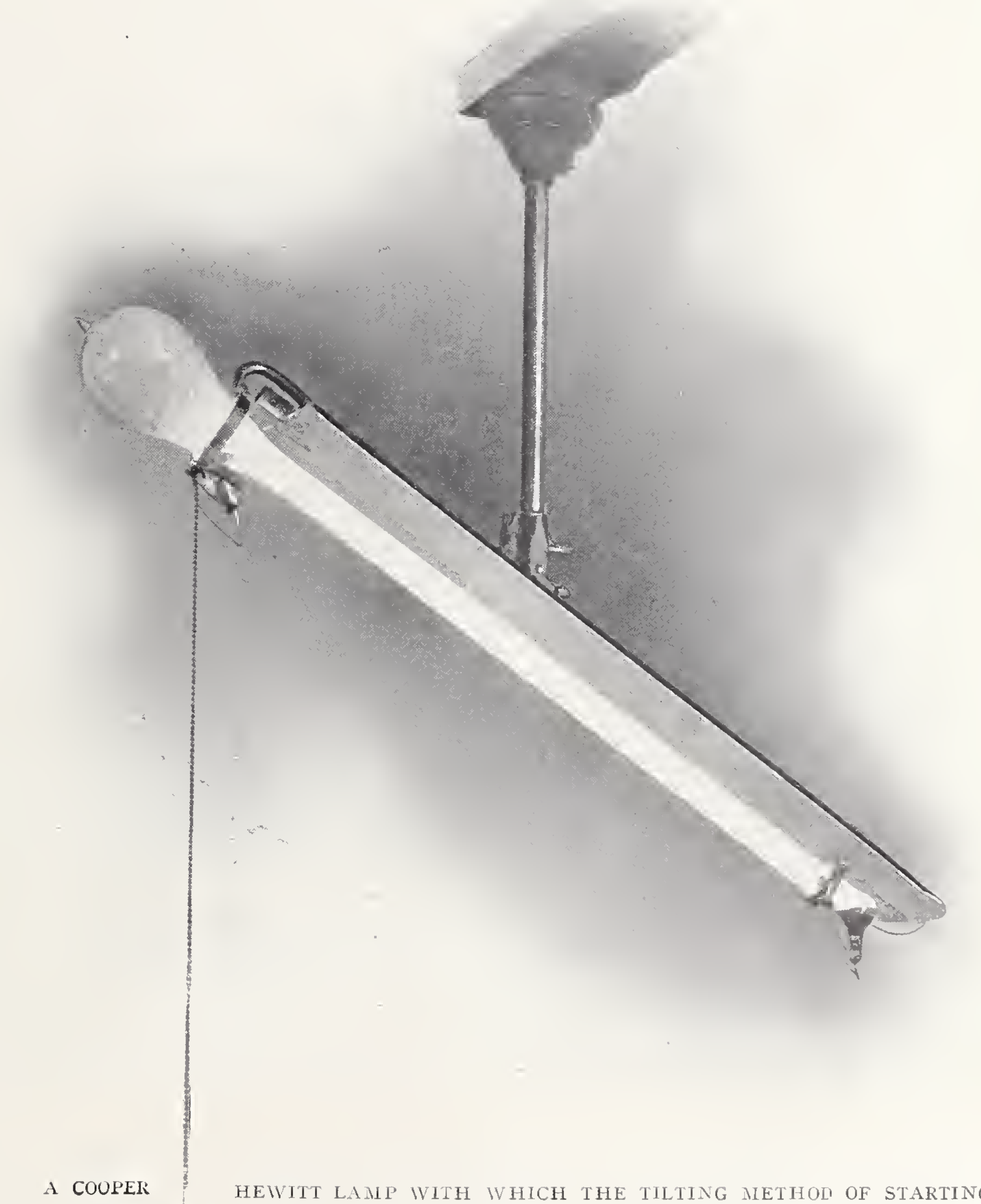
By Dr. A. P. WILLS

WHEN Dr. Cooper Hewitt undertook to develop a new source of illumination which should be at once easily capable of practical application and more economical in operation than the methods then in use, he selected one of the most difficult of the prominent physical problems which for a long time have been crying for solution. That he has in large measure succeeded in his quest for a solution of the problem which he undertook, is evidence of the endless perseverance and high order of experimental skill necessarily employed.

As a result of continuous study in the laboratory for many years, the making of thousands of experiments, the expenditure of much money, and a fixed determination not to be beaten by the vagaries of inanimate matter, the Cooper Hewitt mercury vapor lamp is now a commercial success, with a wide field of application opening before it. The new lamp is an electrical device for producing light, in which mercury vapor is employed to conduct a current of electricity, the vapor emitting an intense light during the process. The important feature of the lamp is that it transforms a greater portion of a given amount of electrical energy into the form of light energy than does any other known device.

The lamp consists essentially of a glass tube, from which all the air has been exhausted, but which contains a small amount of liquid mercury and is filled with mercury vapor. At the ends of the tube are means for introducing the electric current. At the positive end the tube swells out, forming a chamber, which, for reasons which will soon be apparent, is called the condensing chamber. A platinum wire is sealed into each end of the lamp. At the positive end the wire connects either with a small puddle of mercury or a piece of iron, according to the type of electrode used, and this constitutes the positive electrode, or anode. At the negative end the wire connects with a small puddle of mercury constituting the negative electrode, or cathode.

The lamp may be made of such dimensions as to make it suitable for a direct-current line of any assigned voltage. Most lamps are designed to run on a line voltage of about 115 volts. A lamp about 4 feet in length and 1 inch in diameter would be suitable for this voltage and would work best on a current of about 3 amperes. Lamps have been made varying in diameter from $\frac{1}{8}$ of an inch to 4 inches,



A COOPER HEWITT LAMP WITH WHICH THE TILTING METHOD OF STARTING IS EMPLOYED. THIS METHOD IS EXPLAINED ON PAGE 19.

Mr. J. F. Mason Mr. J. H. Lukach
Mr. George Westinghouse Mr. Maurice Leblanc

A PORTRAIT GROUP TAKEN BY THE LIGHT OF THE COOPER HEWITT MERCURY VAPOR LAMP

and in length from a few inches to 12 feet.

Before being started, the electrical resistance of a mercury vapor lamp is decidedly different from that which is present while the current is actually flowing; in fact, the resistances under these different conditions are not even of the same order of magnitude. Before a lamp is started, a voltage of thousands of volts may be applied at its terminals without causing a particle of current to flow through it. This extraordinary high resistance is probably, for the most part, due to the peculiar difficulty experienced when it is attempted to make electricity pass from a gas into a metal while the latter is cold. This effect is referred to technically as the negative electrode resistance to starting, or the initial cathode resistance, and was one of the chief difficulties encountered in the development of the lamp. The method of treatment required by this difficulty was very ably discovered by Dr. Cooper Hewitt, who afterwards actually employed the principle of the difficulty in an extremely important invention, namely, the Cooper Hewitt converter.*

This negative electrode resistance to starting may, as pointed out by Dr. Hewitt, be almost totally destroyed in various ways. One method of destroying it, and thus permitting the lamp to operate under ordinary commercial voltages, is to send a small, momentary high-tension current from an inductance coil through the lamp, which at the same time is connected with the low-voltage mains. This high-tension current penetrates the high cathode resistance and the current from the low-voltage mains follows in its wake, as it were, and if this latter current be great enough the high cathode resistance does not again make its appearance until the current is turned off; and if it is desired to relight the lamp the same procedure has to be repeated. To facilitate the starting of the lamp by this method the so-called "starting band" is employed. This is simply a narrow, thin metallic band attached to the outside surface of the lamp in the neighborhood of the cathode, and connected by a wire to the positive terminal of the lamp. The precise nature of the action of this band has not yet been described by Dr. Hewitt.

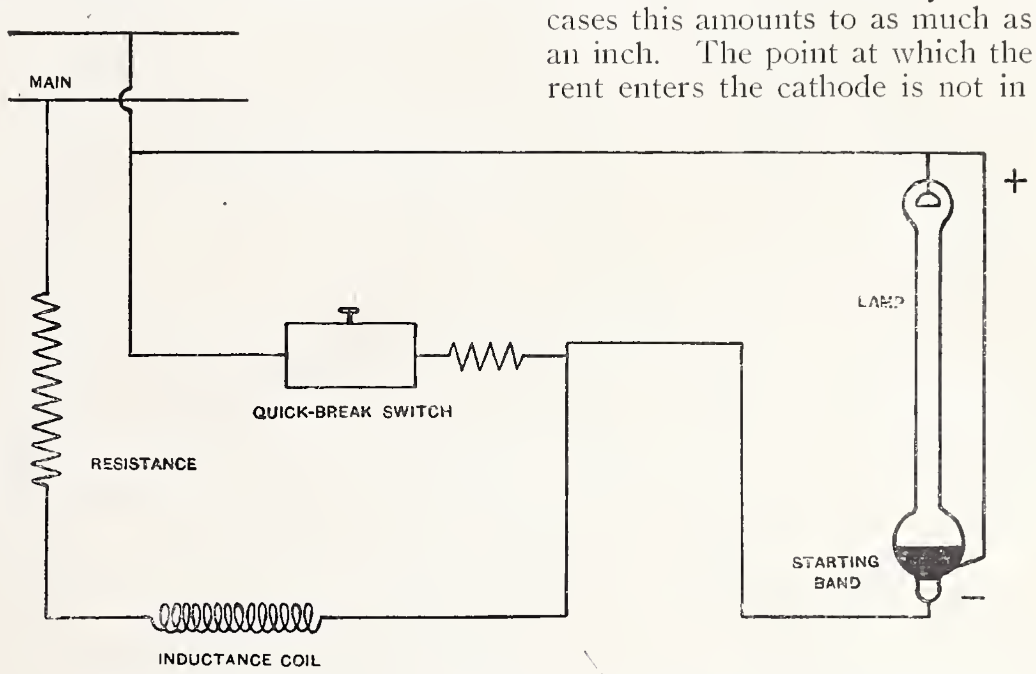


DIAGRAM ILLUSTRATING THE METHOD OF STARTING BY HIGH-TENSION DISCHARGE. TO LIGHT THE LAMP, THE MAIN SWITCH, WHICH IS MOUNTED ON A SMALL PANEL BOARD, IS CLOSED, AND THEN THE LEVER HANDLE ON THE QUICK-BREAK SWITCH IS PRESSED DOWN, THUS COMPLETING A CIRCUIT THROUGH THE SERIES RESISTANCES AND INDUCTANCES, CHARGING THE COIL. ON RELEASING THE HANDLE THE QUICK-BREAK SWITCH AUTOMATICALLY OPENS THE CIRCUIT AND THE DISCHARGE OF THE COIL PASSES THROUGH THE LAMP, BREAKING DOWN ITS RESISTANCE AND ESTABLISHING A PATH FOR THE MAIN CURRENT

Another method of starting is known as the "method of contact." This consists simply in tilting the lamp until the two electrodes are brought into connection by a thin stream of liquid mercury along the length of the tube; then, upon tilting back, a current is started which prevents the high cathode resistance from making its appearance, and the lamp continues to operate until the current is turned off.

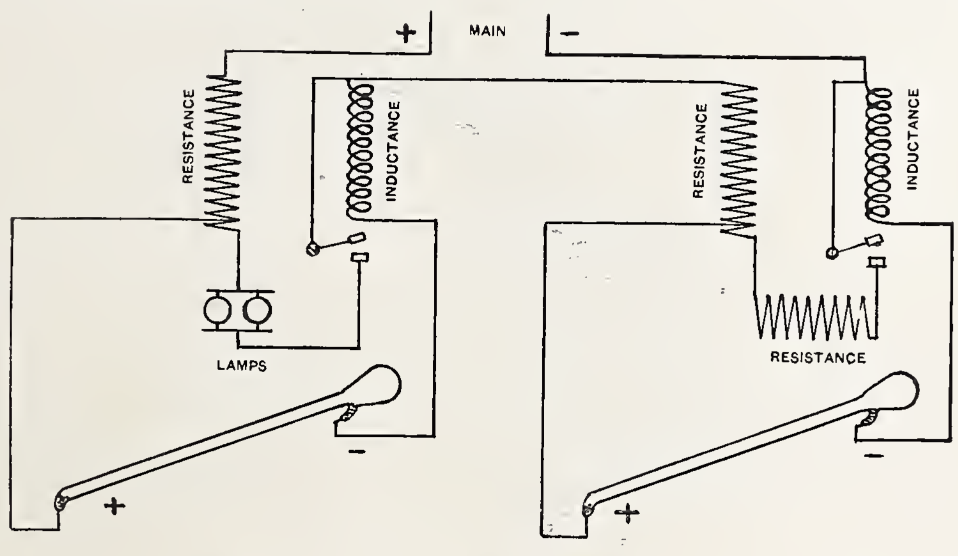


DIAGRAM ILLUSTRATING THE METHOD OF OPERATING LAMPS IN SERIES

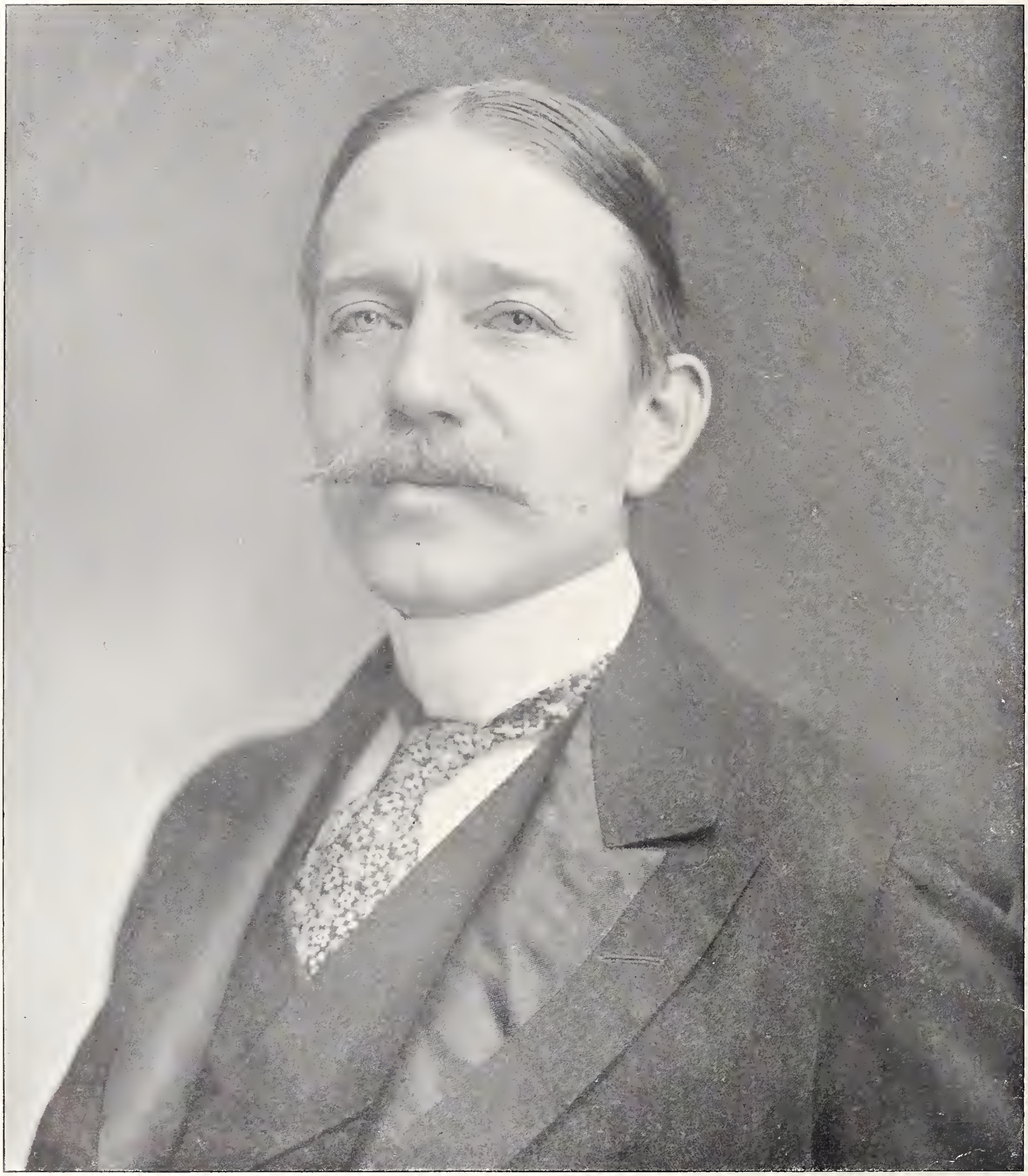
While the lamp is operating, the current usually enters the mercury cathode at a single luminous point, indicating that just there the temperature is quite high. At this point there seems to be a marked depression in the surface of the mercury. In some cases this amounts to as much as $\frac{1}{8}$ of an inch. The point at which the current enters the cathode is not in general stationary, but dances around, apparently aimlessly, over the surface of the mercury. This dancing effect can be easily prevented, however, by allowing the platinum wire which connects the mercury cathode to the outside circuit to protrude slightly above the surface of the mercury; in this case the current prefers to enter the cathode where the wire emerges from its surface, and the dancing effect vanishes.

At the anode, where the current is introduced into the vapor, some peculiar effects are observed; but they are not comparable in interest with the phenomena which the cathode presents.

The current is carried through the lamp itself by the mercury vapor which is present within it. It is not proposed, however, to discuss in this article the theory of the mechanism of conduction. In all probability the modern theory of electrons, as developed by Prof. J. J. Thomson and his students, will prove adequate to explain the facts observed.

It should be noted that the molecules of the conducting vehicle, the mercury vapor, are enormously more widely separated than are the molecules in ordinary metallic conductors. This difference involves, for the case of the vapor, marked changes in the laws of resistance applicable to the more familiar forms of conductors.

*Particulars and illustrations of the Cooper Hewitt converter will be found in a separate article on pages 23, 24 and 25.—The Editor.



A RECENT PORTRAIT OF DR. PETER COOPER HEWITT

The laws of electrical resistance for the vapor are very much more complex. They have, however, been tolerably well unraveled. The voltage which a lamp will require in order to produce a given flow of current can be predicted with considerable accuracy, provided the geometrical data of the lamp are given.

The resistance which a mercury vapor lamp offers to the passage of electric current may be separated into three distinct parts:—First, the resistance encountered by the current in passing from the anode into the vapor; second, the resistance of the vapor column itself; and third, the resistance encountered by the current in passing from the vapor into the cathode.

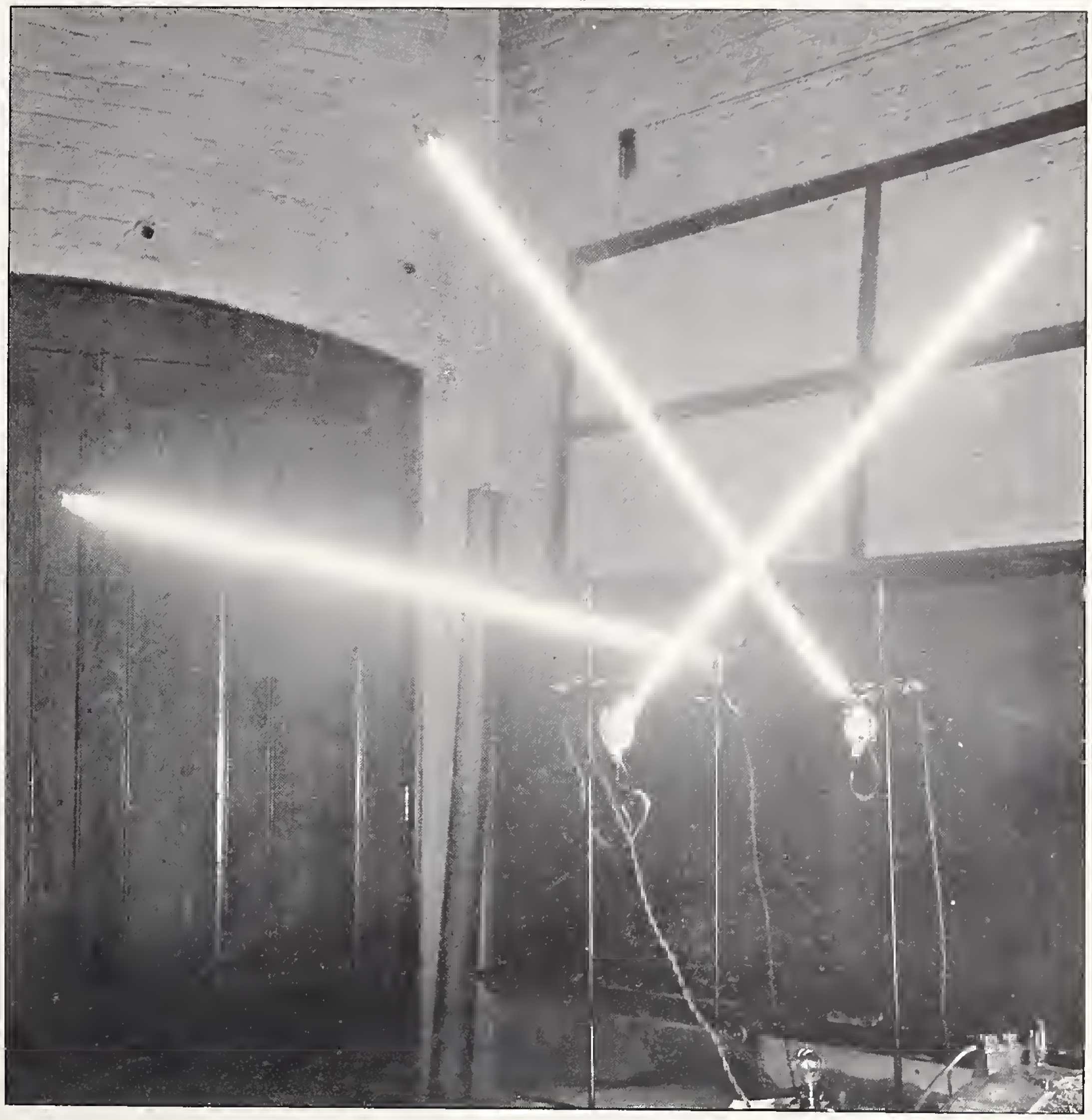
In the commercial lamp the potential drop over the anode is about eight volts and is approximately independent of the magnitude of the current flowing and the diameter of the tube. The anode resistance, then, varies inversely with the current. The potential drop over the cathode is about five volts and is approximately independent of the diameter of the tube and of the magnitude of the current flowing, provided that the current is above a certain minimum value, depending upon the inductance and resistance in series with the lamp. If the current falls below this minimum value, the cathode resistance immediately becomes enormous and the lamp goes out. A certain amount of inductance and resistance is usually placed in series with the lamp, as this has a beneficial effect, causing the lamp to operate more steadily.

The laws of resistance of the vapor column to the passage of the electric current are not so easily summed up. The difficulties in the way of discovering these laws were numerous and perplexing. It was early recognized that four quantities were predominant in fixing the resistance of the vapor to the passage of the current, namely, the length of the tube, the diameter of the tube, the magnitude of the current, and the density of the vapor. But to devise means by which the effect of each of these quantities could be separately investigated and to perform the necessary experiments constituted a task requiring many months of painstaking labor. However, the necessary data were finally obtained and are now being discussed with the view of formulating them so far as possible.

The results can be roughly expressed as follows:—The resistance of a lamp increases directly with its length; it decreases with increase of its diameter and at a greater rate when the current and diameter are small and the vapor density large; it decreases with increase of the current and at a greater rate when the current and diameter are small and the vapor density large; it increases with increase of the vapor density and almost directly, although at a certain value of the density (varying with different currents and different diameters), the rate of increase changes somewhat abruptly and is less for values of the density greater than this value than it is for lesser values.

When the vapor density is quite high, say for values greater than those corresponding to a pressure of three millimeters of mercury, the luminous column no longer fills the tube; and when the density is very high it is of very small cross-section and passes along the axis of the tube. The vapor pressure of a lamp operating under normal conditions is in the neighborhood of one millimeter of mercury.

It has been observed by Dr. Hewitt that there is a value of the vapor density at which the light efficiency of a lamp is greatest, and lamps are designed to run at this density when they are to be operated under commercial conditions. In order to maintain the density at the proper point the condensing chamber mentioned at the beginning of this article is employed. This chamber usually, though not necessarily, surrounds the positive electrode at the upper end of the lamp. By virtue of its size it has a considerable radiating surface exposed to the air and consequently the temperature within it, except in that portion of it which is quite close to the electrode, is low, compared with that in the other parts of the lamp. In consequence of this the pressure also is low in this region, and the mercury vapor from the main part of the tube rushes into the chamber and condenses there. The effect of all this is to keep the vapor density in the conducting column at a lower value than it would otherwise assume.



A REPRODUCTION OF A PHOTOGRAPH OF THREE COOPER HEWITT LAMPS, TAKEN BY THEIR OWN LIGHT

By making the condensing chamber of the proper dimensions, the vapor density can easily be made that corresponding to the greatest light efficiency. In connection with all this, it should be remembered that the mercury at the cathode is continually vaporizing, owing to the heat produced by the current. After condensing in the condensing chamber the mercury falls back into the cathode end, and after a while again takes its turn at being vaporized.

By means of thermo-couples the mean temperature inside of the lamps has been measured. This, of course,

REPRODUCED FROM A PHOTOGRAPH TAKEN BY THE LIGHT FROM THE LARGE LAMP HERE SHOWN

depends on the current, diameter, and density of the vapor. But ordinarily it is not so very high,—a few hundred degrees Centigrade at the most.

In a casual examination of the Cooper Hewitt lamp the most striking feature is the color of the light which it emits. This, to be appreciated, must be seen. It is difficult to describe. Perhaps if one spoke of the light as seemingly having a yellowish-bluish-green color he would not be far wrong. The reason for this peculiar color becomes evident when the light is examined with a spectroscope. There are visible two somewhat faint orange lines, two very bright green lines, two bright blue lines, and two faint violet lines. But there are no red lines present. This means, of course, that the lamp cannot give off white light, since red is a necessary constituent of white light. The addition of the colors which are present in the light gives a composite color of the peculiar nature referred to above.

From the fact that no red rays are emitted by the lamp, there results under its action a remarkable color distortion for those objects which ordinarily reflect red light. The human face and lips, for instance, assume a decidedly gruesome appearance when

seen by the mercury vapor light. On some accounts, of course, this color distortion is objectionable, and much time has been spent in attempting to discover means for overcoming it; but the problem has not yet been completely solved. Occasional visitors to Dr. Hewitt's laboratory have proposed to solve it by making the tube itself of red glass; but a moment's reflection will show that if this suggestion were carried out, no light at all would emerge from the lamp; for red glass transmits only red light and there would be no red light to transmit.

The light is, however, extremely rich in ultra-violet rays; that is, in the rays which are chemically active. This makes it very valuable in photographic work. In this sort of invisible light it is even richer than the arc light.

Concerning the efficiency of the mercury vapor lamp, it may be said to be from two to three times that of the arc light, and from six to eight times that of the incandescent light.

An Edison Medal

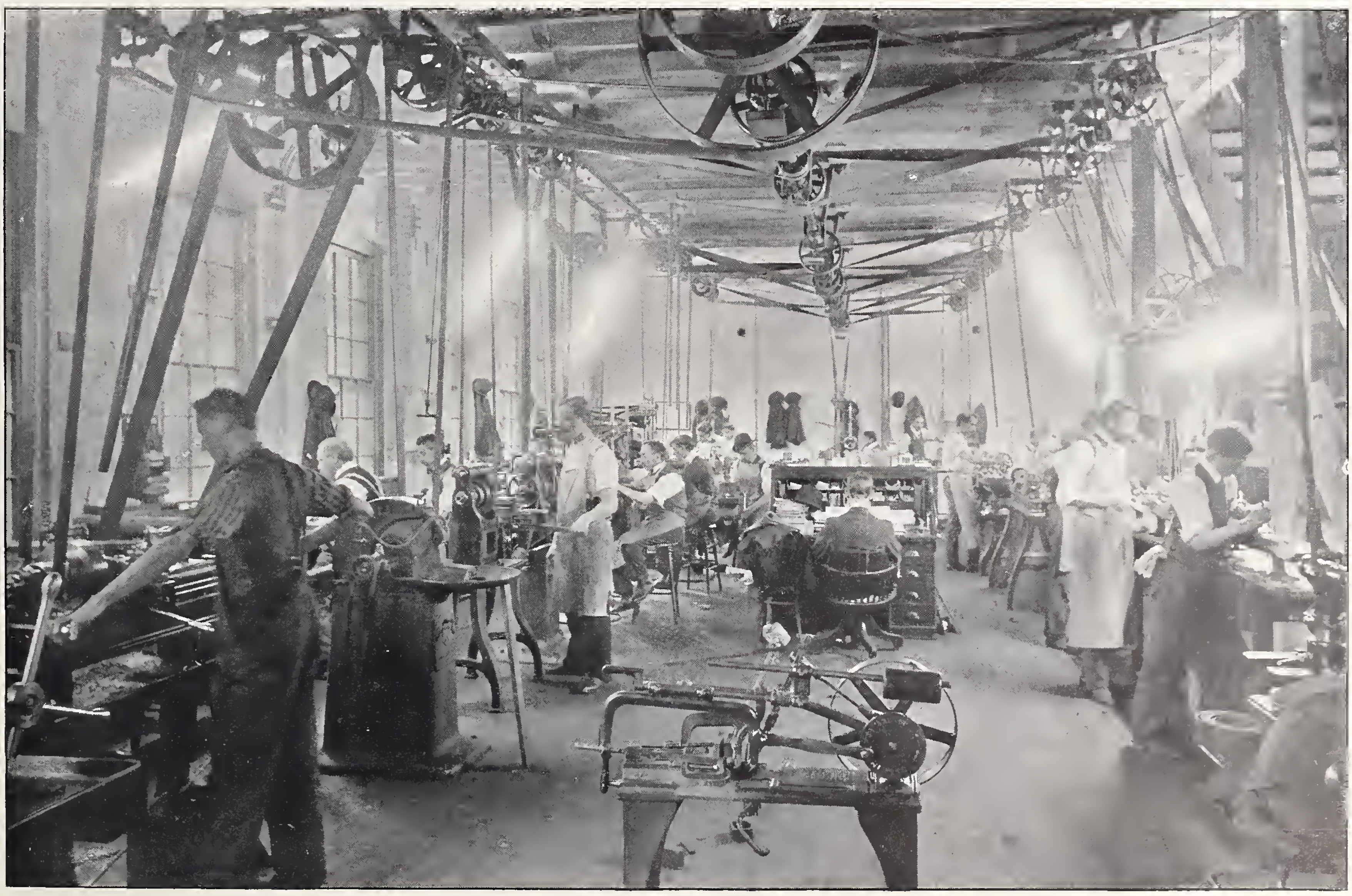
FOR ORIGINAL WORK OF ELECTRIC ENGINEERING STUDENTS.

STEPS have been taken by the friends and associates of Thomas A. Edison to found a medal, to be entrusted to the American Institute of Electrical Engineers, which it is proposed to award annually to graduating students in electrical engineering, in commemoration of the twenty-fifth anniversary of the introduction and commercial development of the incandescent lamp. The Edison Medal Association has been organized to carry this purpose into effect, and it is proposed to present the medal fund at the annual dinner of the American Institute of Electrical Engineers, which will be held at New York on February 11, at which Mr. Edison will be a guest of honor. This date, by the way, is also that of Mr. Edison's birthday.

Through its council, the Institute has accepted the trusteeship of the medal fund. A circular which is being issued by the Edison Medal Association announces that it is the intention to award the medal each year to the graduating student who shall present the best thesis on some original subject. Students from universities of the United States and Canada which have regular courses in engineering will be eligible. Canada has been included, not only because of the fact that Mr. Edison's mother was a Canadian and that part of his life was spent in that country, but because today the Institute not only selects some of its officers from that country, but professors and students are freely interchangeable, considerations which render the inclusion of Canada by the founders of the medal eminently appropriate.

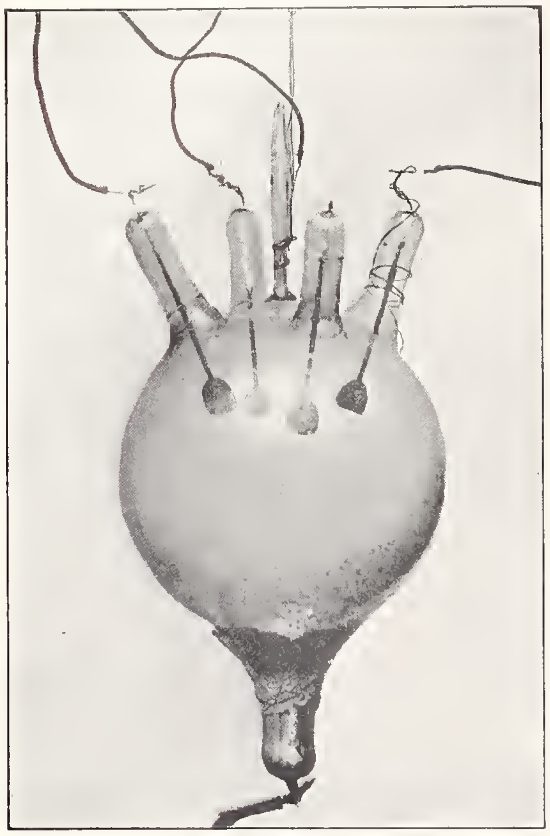
It is proposed that the medal shall be executed by some artist of distinction, and that, if possible, a permanent fund of about $5,000 shall be established for its maintenance. The officers of the Edison Medal Association are the following:—Samuel Insull, chairman; Charles Batchelor, vice-chairman; Frank S. Hastings, 80 Broadway, New York City, treasurer; Robert Ten Eyck Lozier, secretary.

They are re-enforced and assisted by an executive committee of some



THE MACHINE SHOP OF THE COOPER HEWITT ELECTRIC COMPANY IN NEW YORK IS LIGHTED ENTIRELY BY COOPER HEWITT LAMPS, FIVE OF WHICH CAN BE SEEN IN THIS ILLUSTRATION.

thirty others, all of whom have been intimately connected with Edison developments, and by a general committee of one hundred, all of whom have at some time or other been, more or less, closely identified with Mr. Edison's work. The association has also appointed a dinner committee to co-operate with the Institute dinner committee under Mr. Calvin W. Rice, and has appointed other committees on various branches of its work. The executive committee includes Wm. S. Andrews, C. Batchelor, Sig. Bergmann, R. R. Bowker, C. A. Coffin, R. N. Dyer, S. B. Eaton, C. L. Edgar, W. E. Gilmore, W. J. Hammer, C. T. Hughes, F. S. Hastings, S. Insull, E. H. Johnson, F. Jehl, A. E. Kennelly, J. W. Lieb, Jr., H. W. Leonard, R. T. E. Lozier, E. H. Lewis, W. S. Mallory, J. P. Morgan, T. C. Martin, J. Ott, J. P. Ord, E. Rathenau, P. Seubel, F. J. Sprague, E. Thurnauer, S. S. Wheeler and F. R. Upton.



THE COOPER HEWITT STATIC CONVERTER

The interest taken in this movement throughout the Institute ranks and among the many old associates of Mr. Edison is very great, not only because the Edison medal will be the first Institute medal to be founded, but because one of the great epochs in electrical development will be celebrated. At the St. Louis Exposition the twenty-fifth anniversary of incandescent lighting is also to be recognized. The engineering aspects of the occasion can be fitly and legitimately used to identify the American Institute of Electrical Engineering with the lighting art, and by the establishment of the Edison medal fund the sphere of its influence and responsibilities will be enlarged, since the medal is to be put into its charge.

The Cooper Hewitt Static Converter

It is well known that the electric transmission of power can be more efficiently effected by the alternating current than by the direct current, because of the ability to utilize step-up transformers, by means of which the current may be transmitted over the line at a high pressure and low current strength, while, at the distant end, it may be again transformed by step-down transformers to a low pressure and heavy current, such as is used to operate electric traction motors, incandescent lights, and to charge storage batteries. As, however, direct current is used to operate traction motors, and to charge storage batteries, it is necessary to rectify or convert the alternating current into a direct current before it can be thus utilized. For this purpose various devices are employed, such as the motor generator and the rotary converter, the latter being a machine in which the alternating current is received at one terminal of the armature of the converter, which current serves to operate the armature as a motor, and at the same time to rectify the current, which, thus rectified, is delivered at the other terminal of the armature as direct current. As an example of the utility of such machines, it may be mentioned that the great bulk of the electric power employed by the electric traction companies of New York City is transmitted by alternating current at a pressure of about 7,000 volts through cables from the central power station to various sub-stations in different parts of the city, where, by means of rotary converters, the alternating current is converted into direct current at a service pressure of about 500 volts. These rotary converters, while fairly efficient and very useful, in view of the large extent to which by their use it is feasible to employ the alternating current for high-tension transmission, are virtually as expensive and as large as dynamo machines of the same capacity.

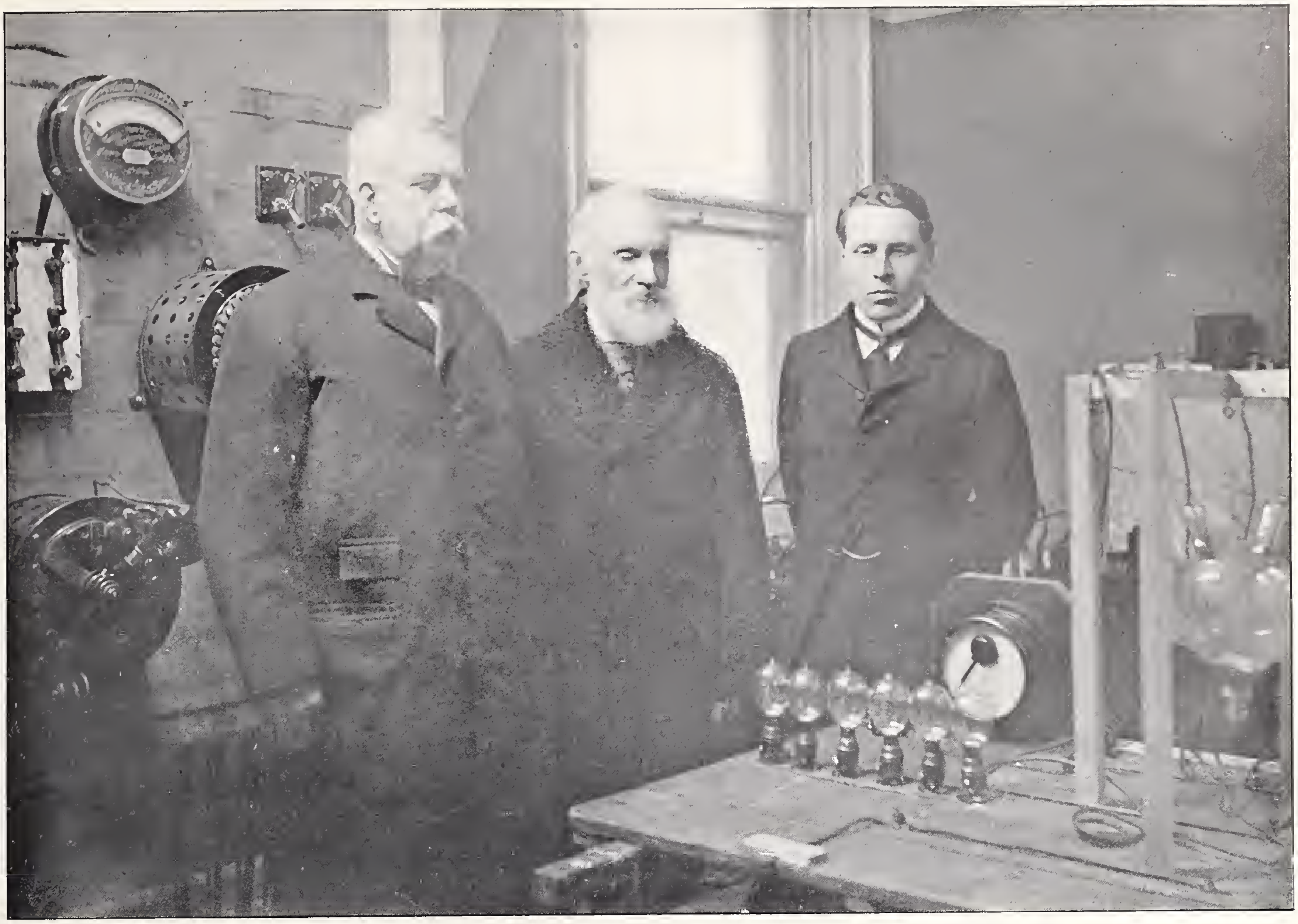
The discovery, therefore, somewhat over a year ago, by Dr. Peter Cooper Hewitt, who has become more particularly prominent electrically through his mercury vapor lamp, referred to at length in the opening article in this issue, of an alternating-current rectifier, in which the space occupied, cost of construction, and complexity are a mere fraction of those of existing rectifiers of equal capacity, is of much importance.

The device, to which the name of static or stationary converter has been applied, is an outcome of his extensive experiments with mercury vapor tubes, and its essential feature is the employment of the property of vapor tubes by which one sign of an alternating current in passing through such a tube may be suppressed. In other words, such a tube permits the passage of a current in but one direction, the electrodes seemingly acting as "electric valves," opening, as it were, to permit the current to flow in one direction through the tube, and closing to suppress the flow in the other direction.

One of the static converters constructed some time ago by Dr. Cooper Hewitt for testing purposes consists of a glass vapor globe, 7 inches in

THE COOPER HEWITT CONVERTER IN OPERATION. REPRODUCTION OF AN INSTANTANEOUS PHOTOGRAPH, TAKEN BY THE LIGHT OF THE CONVERTER

diameter, 9 inches long, and weighing about three pounds. At the top of the globe there are four finger-like projections, as will be noted in the illustrations on this page, through each of which passes a sealed-in electrode. Attached to the end of each electrode, within the globe and near its top, is an inverted iron cup or thimble,—four cups in all. At the



Mr. George Westinghouse Lord Kelvin Mr. Charles Merz

AT A TEST OF THE COOPER HEWITT STATIC CONVERTER. FROM A PHOTOGRAPH TAKEN BY THE LIGHT OF A COOPER HEWITT LAMP.

lower end of the globe there is a mercury electrode. Three of the upper electrodes are connected outside of the globe to the three wires of an alternating-current circuit; the fourth upper electrode is used for starting the current through the globe, practically as is required in the case of the Cooper Hewitt lamp, it having been found that a higher electromotive force is necessary to start the current through such tubes than is required after the current has been started. The mercury electrode is connected to one wire of an ordinary two-wire, direct-current circuit, the other wire of this circuit being connected to the neutral point of the winding of the generator or transformer. The current then enters the upper electrodes as an alternating current; but as one of the signs or polarities of the current is suppressed in the tube, the current passes out at the lower electrode as a pulsating direct current. The fact that the current delivered is a pulsating one is not, however, detrimental, unless the rate of pulsation should be so slow as to cause a flicker on lamp circuits, which result can be readily guarded against, and, on the other hand, such a current is of advantage in charging storage cells.

The troubles of the Curies, famous for their discovery of radium, were many before the now noted couple gained recognition and independence, says a writer in the "Independent." Neither had any fortune, and with the few thousand francs which they earned it was no easy task to make both ends meet at the close of the year in such an expensive city as Paris. So they went out into the suburbs of the great capital and established themselves in the little town of Bourg-la-Reine, distant two or three miles from the walls; and in order to save the railway fare, husband and wife, in all weathers and at all hours, made the journey by bicycle from their modest lodgings to their laboratory in the dingy old Rue Lhomond, where they have made their important discoveries. When it is known that the road from Bourg-la-Reine to Paris is block paved much of the distance and encumbered in many ways, these goings and comings were not holiday rides, especially in the case of the frail young wife.

Electric Street Railways at Calais

According to Consul J. B. Milner, at Calais, France, that town still has horse tramways, operated by an English company, with a franchise to run for seventeen years. The municipality projected an electric-tramway system and was granted the concession by the French Government. The contemplated system is estimated to cost $600,000, in which three lines were comprised, having a length of 16 miles—8 miles within the corporate limits of the city—the contemplated system of traction being the Dickinson trolley. It was intended to commence the construction next spring and have the same in operation within one year. These plans have been upset by the death of the contractor, whose heirs are now trying to sell his rights. This leaves an opening for some company to become his successor by arranging with his heirs. An opportunity may exist here for some enterprising American company.

High-Speed Work in Electric Engineering

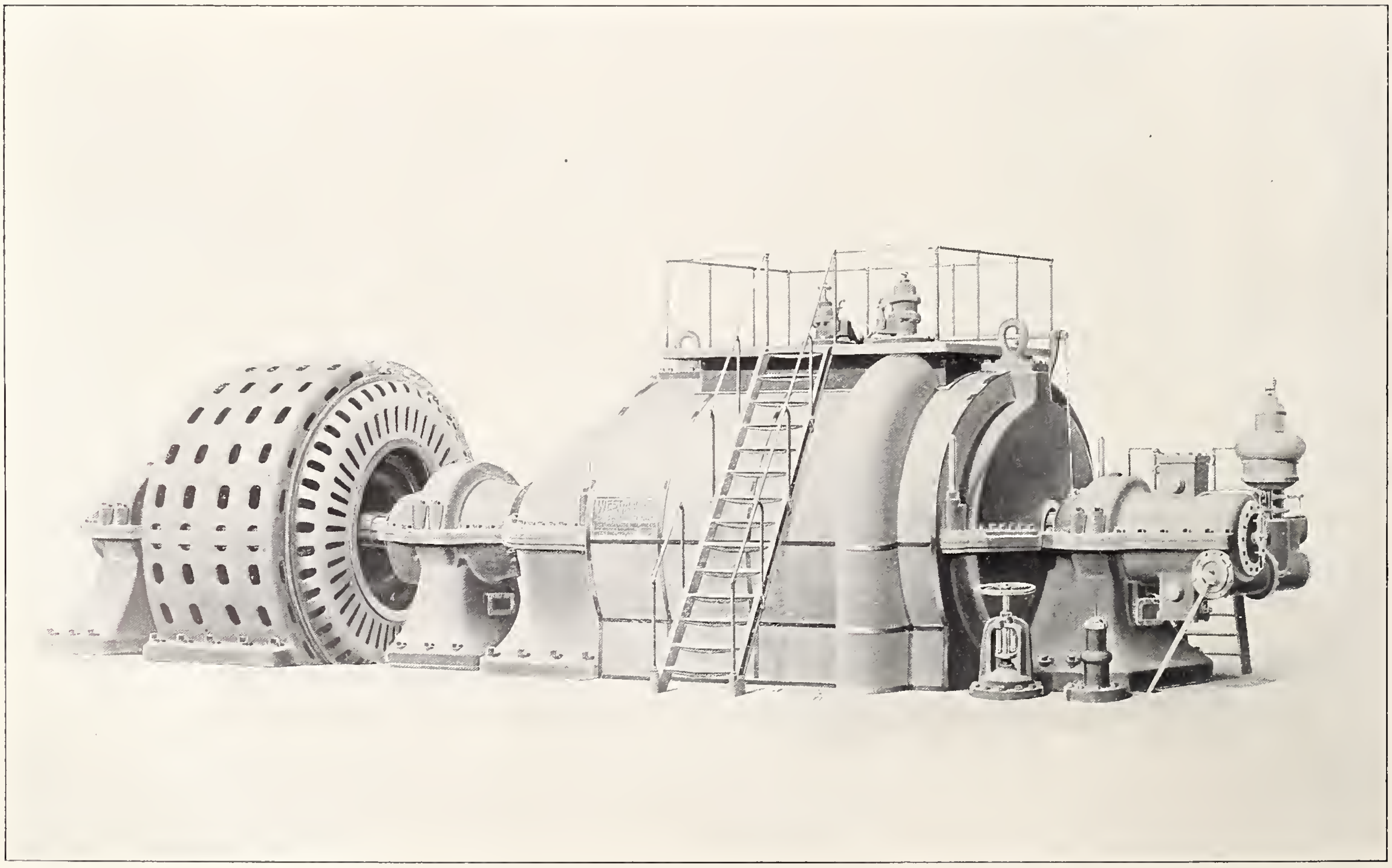
By Dr. B. A. BEHREND

IT is hardly twenty years ago that the electrical engineer embarrassed the steam engineer by demanding a speed for the engine driving his dynamos with which it appeared impossible to comply. The dynamo at that time required for its economic operation speeds which were difficult to obtain in the reciprocating engine then existing, and the evolution of the reciprocating steam engine during the past two decades has been a constant adaptation to the dynamo, with the result that owing to a careful study of the dynamic conditions of the moving masses the speeds of twenty years ago have been doubled and trebled. Ten years ago engines of 2,000 horse power, running at 60 revolutions, were considered to have approached the speed limit, whereas a year ago, engines of 7,000 horse power were put into operation at a speed of 75 revolutions per minute.

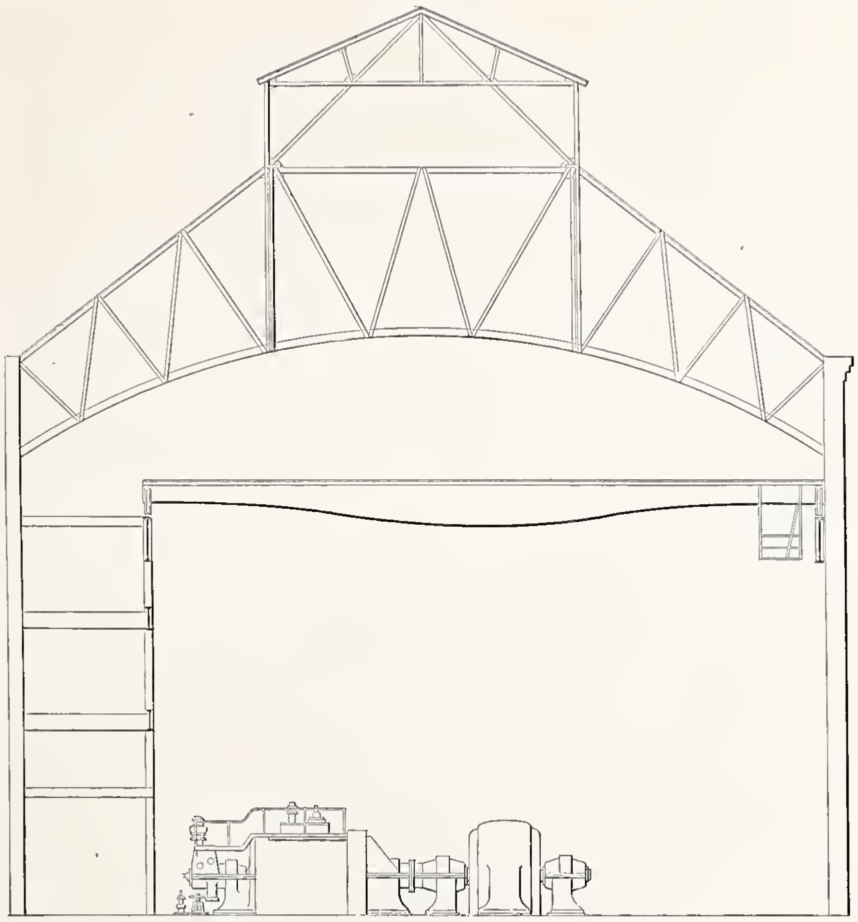
It seems almost like a curious malice of fate that at this hour the state of affairs has become reversed. It is not the engine builder who now finds difficulty in complying with the high speeds of the dynamo builder, but it is the dynamo builder who is confronted with the equally serious problem of adapting his dynamos to the new steam engine,—the steam turbine,—which has apparently so suddenly made its appearance among us. The turbine is a high-speed rotary engine and requires for its best performance a speed not lower than 500 revolutions per minute for 7,000 horse power, against 75 revolutions per minute of the best reciprocating steam engine designed a year ago.

Such an enormous difference in speed must react upon all the industries in which electric power is used. Instead of vertical steam engines, towering 40 and 50 feet above the engine floors, having several stories for their cylinders and valve gears, requiring not only much head room, but also considerable floor space, the steam turbine, small and simple, thrusts itself upon our attention as one of the most important features of the future of engineering. Instead of the huge foundation necessary for the gigantic slow-speed engine, a light foundation answers the purposes of the steam turbine.

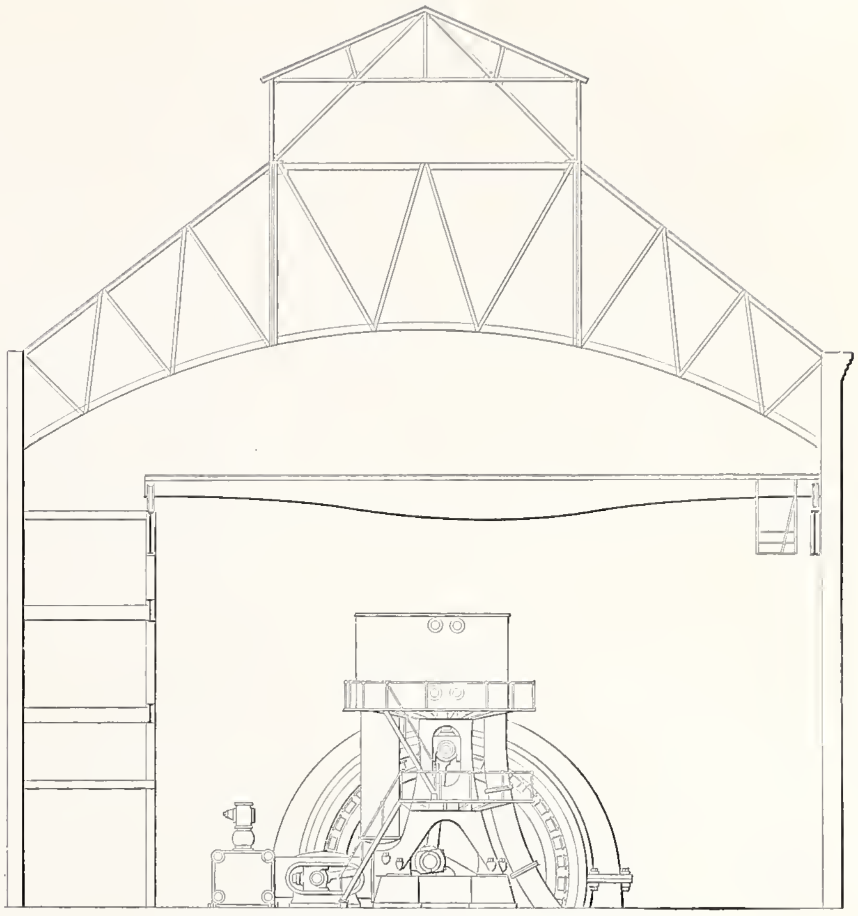
It is true that much has yet to be done to make the steam turbine as reliable a machine as the steam engine; it is true also that much has yet to be done to make the steam turbine generator as satisfactory in regard to heating and regulation as the engine type generator; it is true, again, that much has yet to be done to design and construct a satisfactory direct-current generator for direct connection to steam turbines; but ask what has been the most notable feature of the engineering development of the past year, and the answer must be, "It is the coming in of the high-speed electric generator with a high-speed prime mover."



A 5000 K. W. WESTINGHOUSE-PARSONS TURBO-GENERATING UNIT



CROSS SECTION OF MANHATTAN POWER HOUSE
SHOWING SPACE WHICH WOULD BE OCCUPIED BY 5000 K.W. TURBO-GENERATOR



CROSS SECTION OF MANHATTAN POWER HOUSE
5000 K.W. COMPOUND ENGINE AND GENERATOR

A COMPARISON OF PARSONS STEAM TURBINES AND RECIPROCATING ENGINES IN THE MANHATTAN RAILWAY POWER HOUSE, NEW YORK

Steam Turbine Floor Space Economy

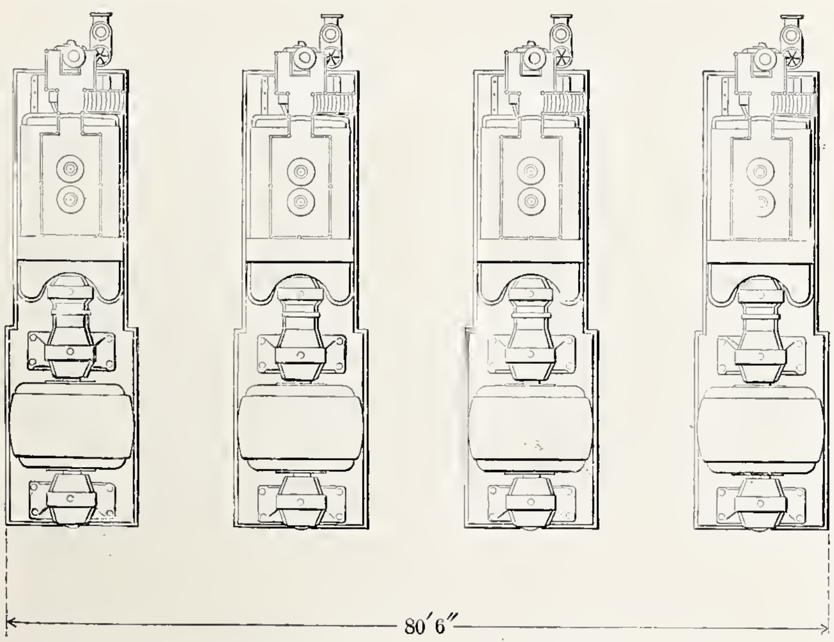
ONE of the important advantages of the steam turbine,—the saving in floor space, to which Dr. Behrend directs attention in a short article on this page,—has thus far received relatively little prominence in all that has been said about turbines. Both afloat and ashore, however, it counts for much. In electric power station equipment, for example, the statement has been made, according to a paper by Mr. H. A. Lardner before the American Institute of Electrical Engineers, that the Westinghouse-Parsons turbine requires about 80 per cent. of the space needed for a vertical, and not over 40 per cent. of that required for a horizontal engine. This statement is based on a station layout with a clear space of 7 feet in all directions between machines. This type of turbine being horizontal, requires less head room and consequently a cheaper building by a considerable amount than the vertical engine. Tabulated data show the required building capacity for such turbines to be about 50 per cent. of that needed for vertical engines.

A better idea of what this saving in floor space means is given by the diagrams on this page, which represent in plan and elevation the comparative space occupied by the 5,000-kilowatt Manhattan Railway (New York) engine type units and the 5,000-kilowatt Westinghouse-Parsons turbine units.

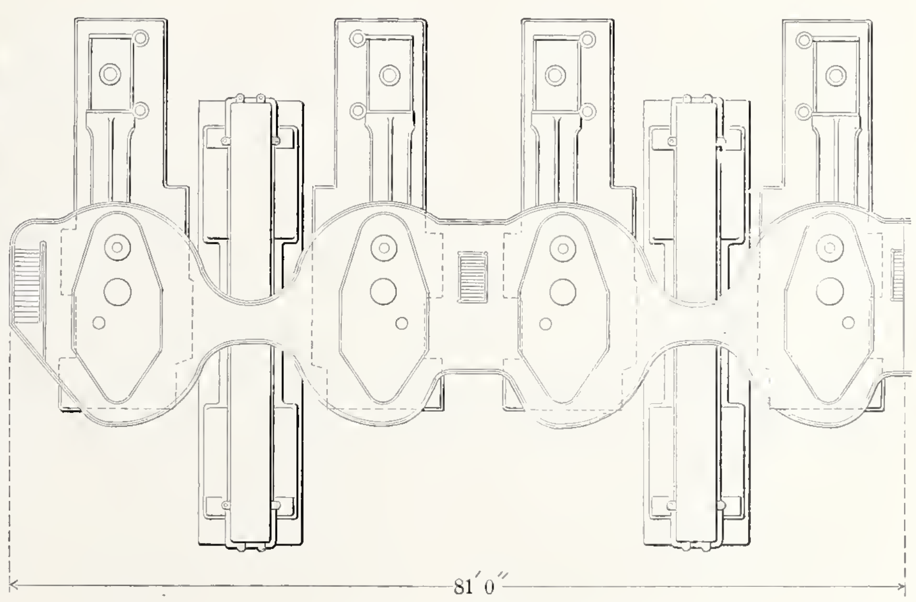
A later comer in this field, the Curtis turbine, controlled by the General Electric Company, of Schenectady, N. Y., which is of the vertical-shaft type, is still more saving in the matter of floor space. The following tables will here prove interesting, giving the principal dimensions of some of the sizes which are now being built:—

CURTIS TURBINES AND GENERATORS.

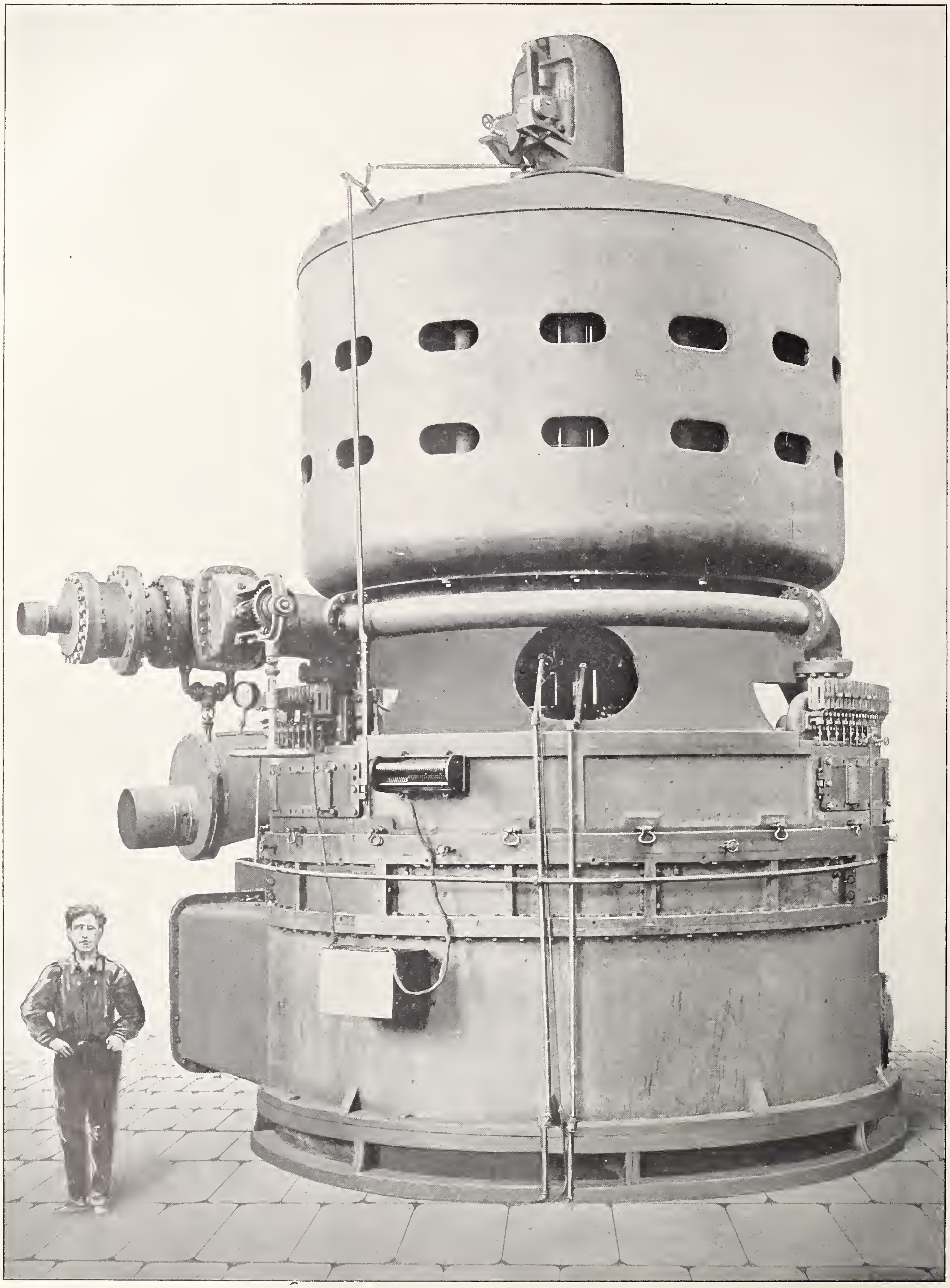
Size KW.	Height ft. in.	Diameter ft. in.	Floor space sq. ft.	R. P. M.
500	12 2	7 8	46.2	1800
1500	16 10	10	78.5	900
3000	22	14	154.	600
5000	27	14 10	175.	500



FOUR 5000 K. W. TURBO-GENERATORS



TWO 5000 K. W. COMPOUND ENGINES AND GENERATORS, SAME AS IN MANHATTAN POWER HOUSE



A 5000 K. W. ALTERNATOR DIRECT-CONNECTED TO A CURTIS STEAM TURBINE. BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

One of the 5,000-kilowatt units of the Curtis vertical-shaft type steam turbines, which has been recently installed by the General Electric Company, is shown on page 28.

WESTINGHOUSE-PARSONS TURBINES AND GENERATORS.

Size KW.	Height ft. in.	Dimensions ft.	Floor Space sq. ft.
400	7 6	19 x 5	95
1000	8	43 x 8	344
5500	15	50 x 12	600

For comparison, the following is the floor space required by the vertical cross-compound condensing engines of a well-known maker. The figures include the space required for an alternating-current generator between the frames:

Size KW.	Dimesions ft.	Floor Space sq. ft.	R. P. M.
500	15 x 22	330	120
1000	21 x 24	504	110
1500	22 x 28	616	100
2500	23 x 32	736	90
3000	23 x 34	782	75

The height of all sizes thus exceeds that of a similar size of vertical turbine.

Telephoning Without Wires

By Dr. ALFRED GRADENWITZ

THE problem of transmitting news without the agency of an intermediate wire has been solved in two ways. Whereas wireless telegraphy, in the hands of Marconi and many other experimenters, has been developed to a relatively high degree, the results so far obtained in wireless telephony are of a more modest kind. Among the methods so far proposed in this connection the scheme suggested by Mr. E. Ruhmer, Berlin, has given most satisfactory results. This system consists of an ingenious combination of two interesting physical phenomena,—first, the photo-electrical effects of selenium conductors; and second, the so-called speaking arc.

Metals and similar substances, though conveying the electric current, will oppose to its passage a certain resistance, this being, as a rule, a well-defined quantity for any given body, apart from slight temperature modifications. Selenium, an element closely related to sulphur, in this respect presents a peculiar behavior, its electrical resistance, which is high in the dark, being found to be lowered to a considerable degree on being exposed to a more or less intense illumination. This interesting property has been utilized in connection with the construction of the so-called selenium cells, which consist mainly of a selenium rod inserted in an electric circuit. When a beam of light falls on this selenium rod its resistance is lowered to a value ranging between one tenth and one-hundredth its initial value. The intensity of the current in the circuit is accordingly increased in proportion, so that any variation in the illumination will result in similar variations in the strength of the electric current. The apparatus thus behaves like an electric cell proper, susceptible of producing and modifying electric currents.

The other phenomenon above mentioned, that of the speaking arc, was discovered by Prof. Simon in 1898. The latter observed that a continuous-current arc lamp would give out very strong, crackling sounds as soon as an electric circuit, traversed by a feeble, intermittent current, was placed in parallel with the arc lamp circuit and in its immediate neighborhood. This phenomenon is produced even by very low currents, so that the weak induction currents of a telephonic circuit are quite sufficient to produce the effect in question. Prof. Simon then made the surprising discovery that the arc could transmit very distinctly any whistling, knocking or musical sounds, and even reproduce words spoken into the transmitter. As, however, the acoustic effect obtained in this way was relatively small, a pair of hearing tubes had to be resorted to. The conditions of these experiments have lately been improved by the use of sensitive carbon-grain microphones, so that the phenomenon may now be demonstrated before a large audience.

The first one to utilize the photo-electric properties of selenium in connection with a wireless telephony, was Alexander Graham Bell, who, in 1880, made some experiments that produced a sensation. The light beam issuing from an arc search light was cast against a reflecting membrane placed at the end of a speaking tube, and was thence reflected to a selenium cell placed in the focus of a concave mirror. When singing or speaking into the speaking tube, the vibrations of the reflecting membrane caused the rays given off by the latter to alternately converge and diverge, thus producing an undulating illumination of a selenium cell, which was connected to two telephones and a battery at the receiving station, this illumination corresponding closely to the acoustic vibrations which strike the membrane.

A WIRELESS TELEPHONE SENDING STATION

As a selenium cell is capable of reacting on very slight differences in illumination, by modifying its resistance the undulating light rays are reconverted into sound waves in the telephones, being more or less analogous with those striking the membrane of the speaking tube.

Bell thus succeeded in obtaining certain communication over distances as high as several hundred yards. By replacing Bell's receiver with the speaking arc flame, Prof. Simon has largely contributed towards rendering this optical telephony available in practice. The practicability of the system in question was not, however, shown until Mr. Ruhmer took up these experiments, and by using his own improved selenium cells and the silvered projectors constructed by the Schuckert Electric Company, he was able to extend the experiments over considerable distances. The first experiments performed outside of a laboratory were his well-known Wannsee trials of last year, when perfect transmission of speech was obtained between the shore of the Wannsee and a boat anchored nearly five miles away.

Some months ago these experiments were further extended in connection with the naval maneuvers in the harbor of Kiel. Four ships were used in these trials, provided with Ruhmer's instruments for wireless telephony. At the beginning the tests took place in the bay of Wyk, the distance being small, and most satisfactory results being obtained. Later on the distance was increased. Immediately before the beginning of the so-called Kiel week, the final experiments were made. By the courtesy of the German Emperor the "Nymphe" was allowed to leave the fleet, stationed at the mouth of the Elbe, before the maneuvers had ended, in order to go to Kiel to participate in the experiments. The distance between the "Nymphe" and the sending station placed on the coast was finally about twenty miles. The working of the instruments was excellent, and apart from some insignificant disturbances the effect obtained was most satisfactory.

On the first day of the Kiel week, the Kaiser was present during the progress of the experiments, and some days previously the chief of the staff of the Admiralty, Vice-Admiral Buechsel, had convinced himself of the usefulness of the new system of transmitting news. Those present could distinctly hear the words spoken on board the "Neptun," anchoring near the military academy. The results obtained by the representatives of the navy as well as by experts fully proved the usefulness of the system for the navy, and they are likely to result in the official adoption of the Ruhmer system in the German Navy.

A WIRELESS TELEPHONE RECEIVER AS USED IN THE WANNSEE TRIALS, NEAR BERLIN

Electricity and Plant Growth

One of the methods of testing the effect of electricity on the growth of plants, and which seems to be most readily accomplished, says the London "Electrical Review," consists in burying plates of zinc and copper on either side of the plant to be experimented upon, and connecting these plates by means of wires placed above ground. The current generated passes through the earth and roots and thus, it is alleged, promotes a more healthy growth.

Static electricity has been utilized for the same purpose. Prof. Lemström, a Russian, has carefully experimented for the purpose of finding the exact nature of the action of electricity in producing these results, and assumes that electricity "produces an augmentation of the energy to which is due the circulation of the sap," and that the "more fertile the soil and the more vigorous the growth, the more satisfactory are the results obtained from electrical treatment."

A WIRELESS TELEPHONE RECEIVER

For example, he cites results obtained by the treatment of beets and potatoes, which showed an increase in harvest of 107.2 per cent. in the former and 76.2 per cent. in the latter case.

Decorative Uses of the Incandescent Lamp

By M. S. SEELMAN, JR.

A NIGHT VIEW OF LUNA PARK, CONEY ISLAND, NEW YORK. A GLITTERING "INCANDESCENT" PANORAMA

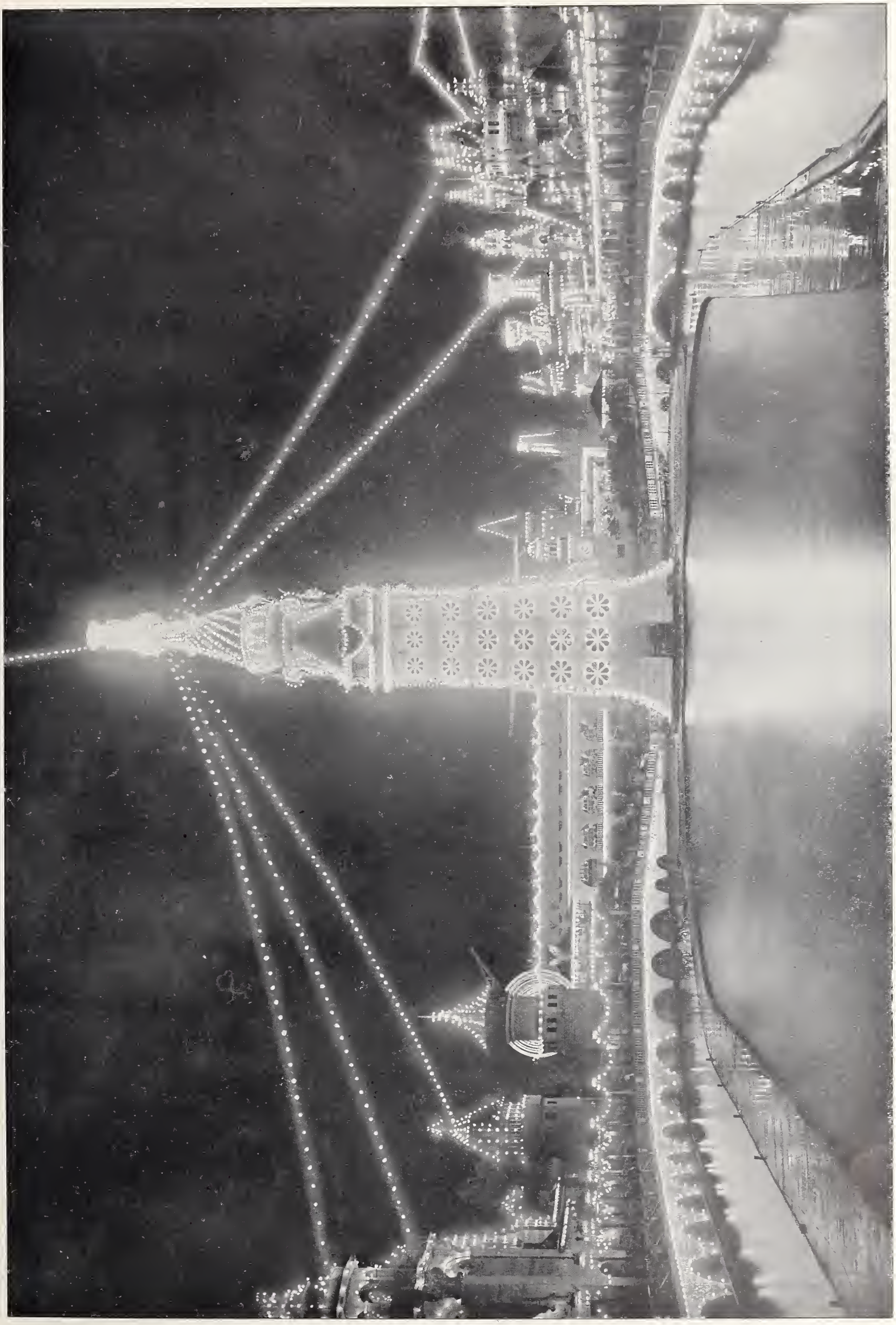
IT is long since we have learned that man does not live by bread alone. The prehistoric cave-man of Western Europe, fierce and squalid though his wretched existence and limited his mental attainments, doubtless derived a pleasure from the flame of his fire quite apart from the bodily satisfaction imparted by its warmth,—a purely æsthetic gratification in the picturesque and attractive properties of light which was a dim adumbration of the delight with which his civilized descendants of the twentieth century viewed such splendid spectacles as those presented, for example, by the electric illumination at the Pan-American Exposition at Buffalo, or the lighting of Luna Park at Coney Island, New York's summer playground.

All light—the opposite of ignorance and night—is beautiful, and throughout the infancy and adolescence of the world this fact was recognized in a thousand ways. But it has remained for the men of our own time, in utilizing the marvelous conception of Edison incarnated in the fragile glass and carbon of the incandescent lamp—that golden drop of light confined within a crystal bulb—to revolutionize, or rather to evolutionize, all ideas of illumination, so that to-day lighting in many of its phases is not only a question of utility but also a manifestation of high art.

To this manifestation the incandescent lamp readily lends itself. Shut up within its empty bulb, the light neither consumes nor pollutes the air, is steady, unflickering, warm, bright, and cheerful, and unaffected by atmospheric conditions. It has an attractive character all its own which does not belong to any other form or method of illumination. What more softly beautiful, for instance, than the diffused light from the reflection of hidden incandescents, by which so many show windows and a few residences are now illuminated? What more strikingly spectacular than the brilliant illumination by means of electric lamps of the outlines of theaters, bridges, office buildings and tall towers? What form of interior decoration for residence, hall, or ball room can compare with the glowing irridescence centered within these roped and clustered vari-colored bulbs?

The man who first raised illumination to the dignity of an art was the late Luther Stieringer. It was he who devised and patented the first safe and practical system for concealing wires in the walls of buildings, and his artistic sense and love of beauty have resulted in some magnificent electrical exhibits, notably the lighting of the

THE NEW BRIDGE OVER THE EAST RIVER, CONNECTING NEW YORK AND BROOKLYN, ON THE OPENING NIGHT, DECEMBER 19, 1903. REPRODUCTION OF A REMARKABLE INSTANTANEOUS NIGHT PHOTOGRAPH, SHOWING THE OUTLINES OF THE STRUCTURE AS ILLUMINATED BY THOUSANDS OF INCANDESCENT LAMPS



NIGHT VIEW IN LUNA PARK, CONEY ISLAND. A SPLENDID EXAMPLE OF THE VALUE OF THE INCANDESCENT LAMP FOR STRIKING AND EFFECTIVE DECORATION

AN ORNATE ENTRANCE DECORATION, EFFECTED PRINCIPALLY THROUGH BRILLIANT ILLUMINATION OF INCANDESCENT LAMPS

Pan-American Exposition, for which he furnished the designs and plans.

E. R. White, in the "Atlantic Monthly," describes this illumination in these glowing words:—

"Standing before the pylons and fronting the esplanade, one sees the slow dusk conquer the massed color, the insistent hues. Dim, like an exhalation is the picture now, and a hush is over the scene. There glows, before one knows it, a premonitory redness along up through the lines of pillars which range themselves in solemn file in the great court. Each pillar is surmounted with a close cluster of lights. And look! The great tower itself is blushing a low red. The red is angry now, sharper and there! daylight is almost here again. Each building has glimmered into light. Electricity has mounted her resplendent throne. But it is not daylight; it is something almost better, refined daylight,—less frank, less brutal, less modern. Suddenly from everywhere there has come a light which is more than a glow, but less than a glare. In a second or so, the Exposition has grown from a city of shadow to a vision of light. And such a vision, and such a light!"

Coney Island, the seaside playground for the four million residents of the New York metropolitan district, in recent years has grown to be a center for artistic and decorative electric lighting. This tendency culminated last season in the advent of Luna Park, an extensive and high-class amusement resort, the main attraction of which was its profuse and magnificent lighting by means of many thousands of incandescent lamps. The scheme of this illumination was planned in all its details and superintended in construction and operation by Hugh Thomas, an electrical engineer of great originality. The Park, when illuminated, was a grand spectacle, visible for miles; and so successful from a financial standpoint did it prove to its projectors that for next summer another similar amusement enterprise, but on a much larger scale, has been organized, and under the title of "Dreamland" expects to be ready for business at Coney Island, with a multitude of attractions and a myriad of electric lights. The magnitude of this new enterprise may be appreciated when it is stated that the Brooklyn Edison Company has recently closed with the directors of "Dreamland" what is believed to be the largest contract for permanent service ever made by any central station in the world, the number of incandescent lamps provided for in the plans being greater than was the entire electric lighting installation of the whole of Coney Island, including Luna Park, in 1903.

In addition to the Luna Park illustrations accompanying this article, as specimens of artistic and effective decorative lighting, two other pictures of the Coney Island of last season are given, one of the highly ornate entrance to Bostock's Animal Show, with the Thompson Scenic Railway adjoining; the other of Louis Stauch's great dancing pavilion, which was destroyed in the recent fire. These are reproduced from night photographs and are faithful reflections of the beauty and attractiveness incident upon the picturesque illumination of the incandescent lamp.

It is difficult, in considering the decorative in lighting, to fix the exact point where utility ceases and decoration, per se, begins. The line of demarcation is very faint and the combinations too many and frequent. The electrically illuminated sign, for in-

stance, the use of which has increased with remarkable swiftness within the last year or two in all large cities, while eminently useful from a business standpoint as highly effective advertising, is, at the same time, often a thing of beauty, and wherever these signs are in general use they constitute in themselves a brilliant attraction which results in greater crowds, increased activity and more business. They form a distinctive feature or factor of that metropolitan atmosphere which has such an alluring and magnetic charm for almost everybody.

A development of the ordinary electric sign—the "talking sign," as it has been called, presents some very attractive and artistic features. This sign is made up of a number of "monograms," each of which is a collection of metal troughs, studded with incandescent bulbs and joined together in such a manner that all the letters of the alphabet and the numerals may be formed by lighting certain of these troughs in combination. Each trough is whitened on the inside to reflect the light, and the front of the monogram is covered with glass of any color or of various colors.

The letters are changed in the monograms by a commutating device revolved by a small fan motor, and each letter or number has its own letter-bar, which bars are practically the type used in making up the reading of the sign. The mechanism is so arranged that forty words or phrases may be successively flashed out (the length of each depending upon the number of monograms in the sign) by simply turning on the current, and the sign will go on repeating them automatically until stopped. The effect is striking.

Church lighting by incandescent clusters is certainly a combination of the useful and the decorative. So far, in the history of invention and discovery, no light has been produced which can, for church illumination, be compared to the chastened sunshine of the incandescent lamp. It is in thorough and complete harmony with churchly architecture.

For home decoration the incandescent lamp may be used in a thousand and one ways. With it artistic effects are possible which could not be thought of with any other method of lighting. A picturesque and pleasing effect is achieved in a certain dining-room, lighted by forty electric lamps with alabaster globes set in the ceiling beams. The light from these is soft and beautiful and yet all-pervasive. It is expensive, too, but may be used on state occasions, while for ordinary purposes a central chandelier, inclosing a cluster of three or five incandescents, supplies adequate illumination.

The General Electric Company has recently put upon the market a decorative lighting outfit, which will be found convenient and attractive in any household equipped for electric lighting. It was designed primarily for the illumination of Christmas trees, but can as readily be utilized for general household decoration,—upon the table, about the walls, or around columns, over a balustrade, or festooned from chandeliers. It consists of fifty odd feet of flexible cord, with tiny sockets, arranged in three-branch festoons, and twenty-eight one-candle power miniature lamps in plain and colored bulbs. The cord is draped as desired, the little lamps are placed in their sockets, the connecting plug is attached to the nearest electric fixture, and the outfit is ready for use. It makes a safe and effective decoration and the cost is reasonable—something in the neighborhood of $10.

The limits of this article permit no further amplification of the decorative uses of the incandescent lamp, a subject which might be dwelt upon almost indefinitely. A few of these uses have been briefly outlined rather than described. And it is to be remembered that they all are, practically, developments of the past ten years.

For the photographs from which the illustrations accompanying this article were reproduced, credit is due to the Edison Electric Illuminating Co., of Brooklyn, who supplied the illumination in the several cases.

LUNA PARK ENTRANCE, BRILLIANTLY OUTLINED IN INCANDESCENT LAMPS, AND SHOWING A VISTA OF THE MYRIAD LIGHTS WITHIN

The Interurban Street Railway Company, of New York City, will convert its remaining horse car lines to underground trolley in 1904.

The Gilbert Tercentenary Celebration

THE three hundredth anniversary of the death of Dr. William Gilbert, of Colchester, England, was celebrated in a fitting manner by the Institution of Electrical Engineers in London, on December 10, the date of Gilbert's death. One of the main features of the celebration was the formal presentation to the mayor and borough of Colchester of a picture by Mr. Acland Hunt, representing Dr. Gilbert showing his electrical experiments to Queen Elizabeth and her court. Among those present were Sir William Huggins, president of the Royal Society; E. Hospitalier, president of the Société Internationale des Electriciens; Sir Dyce Duckworth, treasurer of the Royal College of Physicians; and Dr. J. Larmor, F. R. S., of St. John's College, Cambridge, Dr. Gilbert's college.

To Silvanus P. Thompson, who has made Gilbert's achievements the subject of a special study, was allotted the task of preparing some notes on his life and career for publication on this occasion. Dr. Thompson in these notes traced the foundation of the electrical science to the publication in 1600 of the "De Magnete" of Dr. Gilbert. In a short introduction he said:—"Gilbert's renown rests not on his eminence as a physician, but on his achievements in the foundation of the twin sciences of electricity and magnetism. He is beyond question rightfully regarded as the father of electric science. He founded the entire subject of terrestrial magnetism. He also made notable contributions to astronomy, being the earliest English expounder of Copernicus. In an age given over to metaphysical obscurities and dogmatic sophistry, he cultivated the method of experiment and of reasoning from observation, with an insight and success which entitles him to be regarded as the father of the inductive method. That method, often accredited to Bacon, Gilbert was practicing years before him. It seems, therefore, fitting upon the occurrence of the tercentenary of his death to recall Gilbert's achievements as the father of electric science."

Dr. Thompson thus mentioned Gilbert's magnetic discoveries:—"Gilbert's magnetic work has been so often described that a brief summary will here suffice. Trying the properties of loadstones in innumerable experiments lasting over many years, he was led to several notable discoveries, and to one generalization of immense importance. He discovered the augmentation of the power of a loadstone by arming or capping it with soft iron cheeks. Gilbert called such a cap an armatura,—the first occurrence of the term. This invention brought him much fame. In the 'Dialogues of Galileo' Sagredus and Salviatus discuss the arming of the loadstone, and the increased lifting power conferred by adding an iron cap. Salviatus mentions a loadstone in the Florentine Academy, which, unarmed, weighed 6 oz., lifting only 2 oz., but which when armed took up 160 oz. Whereupon Galileo makes Salviatus say:—'I extreamly praise, admire, and envy this authour for that a conceit so stupendious should come into his minde. . . . I think him [i. e., Gilbert], moreover, worthy of extraordinary applause for the many new and true observations that he made, to the disgrace of so many fabulous authours, that write not only what they do not know, but whatever they hear spoken by the foolish vulgar, never seeking to assure themselves of the same by experience, perhaps, because they are unwilling to diminish the bulk of their books.'

"Gilbert also discovered the screening effect of a sheet of iron; the method of magnetizing iron by hammering it while it lies north and south; the destruction of magnetism by heat; and

A DANCING PAVILION AT CONEY ISLAND. A BRILLIANT EFFECT IS HERE SECURED BY THE LAVISH USE OF ELECTRIC ILLUMINATION. SEE PAGE 31

the existence around the magnet of an 'orbe of virtue'—that is to say, a magnetic field. He perfected the dipping needle of the Norman and other instruments of observation. He collected data as to the declination and inclination of the compass in different regions. Using loadstones of many different shapes, he observed their actions on one another and on compass needles. In particular he studied the magnetic properties of a globular loadstone or terrella, and found that compass needles were directed toward its poles, and dipped at various angles over its surface, just as compass needles do at various regions of the earth's surface.

"Generalizing from small to large, he advanced the entirely novel idea that the globe of the earth is itself a great magnet, thus laying the foundations of the science of terrestrial magnetism. He was particularly keen in disproving the many absurd fables that had grown up about the magnet, such as that the magnet refuses to act in the presence of a diamond, or if touched with garlic. The former he tested by surrounding a loadstone with 70 diamonds. Gilbert denounced the quackery of using loadstone medicinally or in plasters for the cure of wounds. He ridiculed the idea that the variation of the compass was due to imaginary loadstone mountains like those described in the 'Arabian Nights.' He sought to explain it by the local irregularities of the earth's crust, and exemplified his theory by experiments on round loadstones of irregular outline as models. His book, over which he spent 18 years, was published in 1600, and for the next 100 years became the standard work on magnetism. Though denounced by the Church, the theory of terrestrial magnetism was by Gilbert thus firmly established on an enduring basis of fact, and remained a permanent acquisition in science. The publication of the book marked an epoch in scientific development. It was praised by Sarpi, by Galileo, by Kepler. Sir Christopher Wren proposed to erect a statue to its author, while Dryden sang of his enduring fame."

The contribution made by Gilbert to electrical knowledge is contained in the second chapter of the second book of his "De Magnete," and constitutes a digression interpolated into the discussion of magnetic motions. In this chapter Gilbert, after describing the attracting property of amber, lays down the following maxims:—"The difference between magnetics and electrics is that all magnetics run together with natural forces; electrics only allure; that which is allured is not changed by an implanted force, but that which has moved up to them voluntarily rests upon them by the law of matter. Bodies are borne towards electrics; a loadstone draws a loadstone directly at the poles only, in other parts obliquely and transversely, and in this way also they adhere and hang to one another. Electrical motion is a motion of aggregation of matter; magnetical motion is one of disposition and conformation. The globe of the earth is aggregated and coheres by itself electrically. The globe of the earth is directed and turned magnetically; at the same time also it both coheres, and in order that it may be solid, is in its inmost parts cemented together."

AN ARTISTIC THEATER DECORATION, SHOWING ELECTRICALLY ILLUMINATED SIGN AND OUTLINES OF BUILDING. SEE PAGE 31

Dr. Thompson supplies the following valuable summary of Gilbert's electrical work:—"To distinguish his original discoveries from things already known, Gilbert set in the margin of his book asterisks, large or small, in proportion to the importance of the matter. . . . He marked with large asterisks the discovery of the generality of electrifiable bodies, for

which he coined the name electrics, and the observation that electrified bodies attract not straws and chaff only, but equally attract metals, woods, earths, and even oil and water. The logical outcome of this discovery was the invention of the versorium or electroscope. The method of trying everything instead of accepting statements on authority is characteristic of the man; he must bring all to the touchstone of experiment. The authors who raised Gilbert's wrath by ignorantly copying out all the old tales about amber, jet, and loadstone, instead of investigating the facts, were, as he says at the beginning of the chapter, some theologians and some physicians. He seems to have taken a special dislike to Albertus Magnus, to Puteanus, to Paracelsus, and to Levinus Lemnius. Gilbert mentions amber and jet as known to become electrical by friction; but the list was not quite so restricted as would appear from this passage. Five, if not six, other minerals had been mentioned, in addition to amber and jet."

The stones referred to by Dr. Thompson comprise the ruby, garnet, jasper, lychnis, and the diamond. Referring to the passage in Gilbert's book, in which he sets forth the differences that exist between magnetic and electric effects, Dr. Thompson says:—"Though Gilbert was the first to explore systematically the differences that exist between the magnetic attraction of iron and the electric attraction of all light substances, the point had not passed unheeded, for we find St. Augustine, in the 'De Civitate Dei,' liber xxi., cap. 6, raising the question why the loadstone which attracts iron should refuse to move straws. The many analogies between electric and magnetic phenomena had led many experimenters to speculate on the possibility of some connection between electricity and magnetism. See, for example, Tiberius Cavallo, 'A Treatise on Magnetism,' London, 1787, p. 126. Æpinus wrote a treatise on the subject, entitled 'De Similitudine vis Electricæ et Magneticæ' (Petropolis, 1758). This was, of course, long prior to the discovery by Oersted in 1820 of the real connection between magnetism and the electric current. It is interesting to note a suggestion of material rays, as the operation of electric forces seems to foreshadow the notion of electric lines of force.

SOME ARTISTIC ELECTRIC SIGNS RECENTLY INSTALLED BY BROOKLYN THEATERS. SEE PAGE 31

"Gilbert had imbibed the schoolmen's ideas as to the relations of matter and form. He had discovered and noted that in the magnetic attractions there was always a verticity, and that in the electrical attractions the rubbed electrical body had no verticity. To account for these differences he drew the inference that since (as he had satisfied himself) the magnetic actions were due to form—that is to say, to something immaterial—to an 'imponderable,' as in the subsequent age it was called—the electrical actions must necessarily be due to matter. He therefore put forward his idea that a substance to be an electric must necessarily consist of a concreted humor which is partially resolved into an effluvium by attrition. His discoveries that electric actions would not pass through flame, whilst magnetic actions would, and that electric actions could be screened off by interposing the thinnest layer of fabric, such as sarcenet, whilst magnetic actions would penetrate thick slabs of every material except iron only, doubtless confirmed him in attributing the electric forces to the presence of these effluvia. There arose a fashion, which lasted for over a century, for ascribing to 'humours,' or 'fluids,' or 'effluvia,' physical effects which could not otherwise be accounted for.

"In spite of his care to test everything by experiment, Gilbert fell into several errors. He denied the existence of electric repulsion, and whilst he strenuously affirmed that the magnetic forces were mutual between the magnet and the iron, each being urged toward the other, he also affirmed that, in the case of the action of the electric on the object which moved toward it, the action was not mutual, but was a one-sided force—an impossibility in physics. Gilbert's experimental discoveries in electricity may be summed up as follows:—(1) the generalization of the class of electrics; (2) the observation that damp weather hinders electrification; (3) the generalization that electrified bodies attract everything, including even metals, water, and oil; (4) the invention of the non-magnetic versorium or electroscope; (5) the observation that merely warming amber does not electrify it; (6) the recognition of a definite class of non-electrics; (7) the observation that certain electrics do not attract if roasted or burnt; (8) that certain electrics when softened by heat lose their power; (9) that the electric effluvia are stopped by the interposition of a sheet of paper or a piece of linen, or by moist air blown from the mouth; (10) that glowing bodies, such as a live coal, brought near excited amber discharge its power; (11) that the heat of the sun, even when concentrated by a burning mirror, confers no vigor on the amber, but dissipates the effluvia; (12) that sulphur and shellac when aflame are not electric; (13) that polish is not essential for an electric; (14) that the electric attracts bodies themselves, not the intervening air; (15) that flame is not attracted; (16) that flame destroys the electrical effluvia; (17) that during south winds and in damp weather, glass and crystal, which collect moisture on their surface, are electrically more interfered with than amber, jet, and sulphur,

which do not so easily take up moisture on their surfaces; (18) that pure oil does not hinder production of electrification or exercise of attraction; (19) that smoke is electrically attracted, unless too rare; (20) that the attraction by an electric is in a straight line toward it.

"Gilbert's list of electrics should be compared with those given subsequently by Cabeus (1629), by Sir Thomas Browne (1646), and by Bacon. The last-named copied out Gilbert's list almost without change. Sir Thomas Browne's list is given in the following passage, which is interesting as using for the first time in the English language the noun electricities:—'Many stones also both precious and vulgar, although terse and smooth, have not this power attractive; as Emeralds, Pearle, Jaspis, Corneleans, Agathe, Heliotropes, Marble, Alablaster, Touchstone, Flint, and Bezoar. Glasse attracts but weakely though cleere, some slick stones and thick glasses indifferently: Arsenic but weakely, so likewise glasse of Antimony, but Crocus Metallorum not at all. Saltes generally but weakely, as Sal Gemma, Alum, and also Talke; nor very discoverably by any frication: but if gently warmed at the fire, and wiped with a dry cloth, they will better discover their Electricities' ('Pseudodoxia Epidemica,' p. 79).

"If, as shown above, the electric powers of the diamond and ruby had already been observed, yet Gilbert was the first beyond question to extend the list of electrics beyond the class of precious stones, and his discovery that glass, sulphur, and sealing wax acted, when rubbed, like amber, was of capital importance. So was also his observation that electrical experiments succeed better in dry or frosty weather. Though he did not pursue the discovery into mechanical contrivances, he left the means of that extension to his followers.

"To Otto von Guericke we owe the application of sulphur to make the first electrical machine out of a revolving globe; to Sir Isaac Newton and to Francis Hawksbee the suggestion of glass as affording a more mechanical construction. And both materials were discovered by Gilbert to be electrics.

"'Such,' said Priestley in 1767, 'were the discoveries of our countryman Gilbert, who may justly be called the father of modern electricity, though it be true that he left his child in its very infancy.' To Priestley's quaint remark we may add that as electricity is no longer in its infancy, we who claim Gilbert as our countryman are all the more proud to acknowledge his just claims to its paternity."

The Most Economical Amount of Feed Wire for an Electric Railroad

A Graphic Method of Determination

By L. W. SERRELL, M. E.

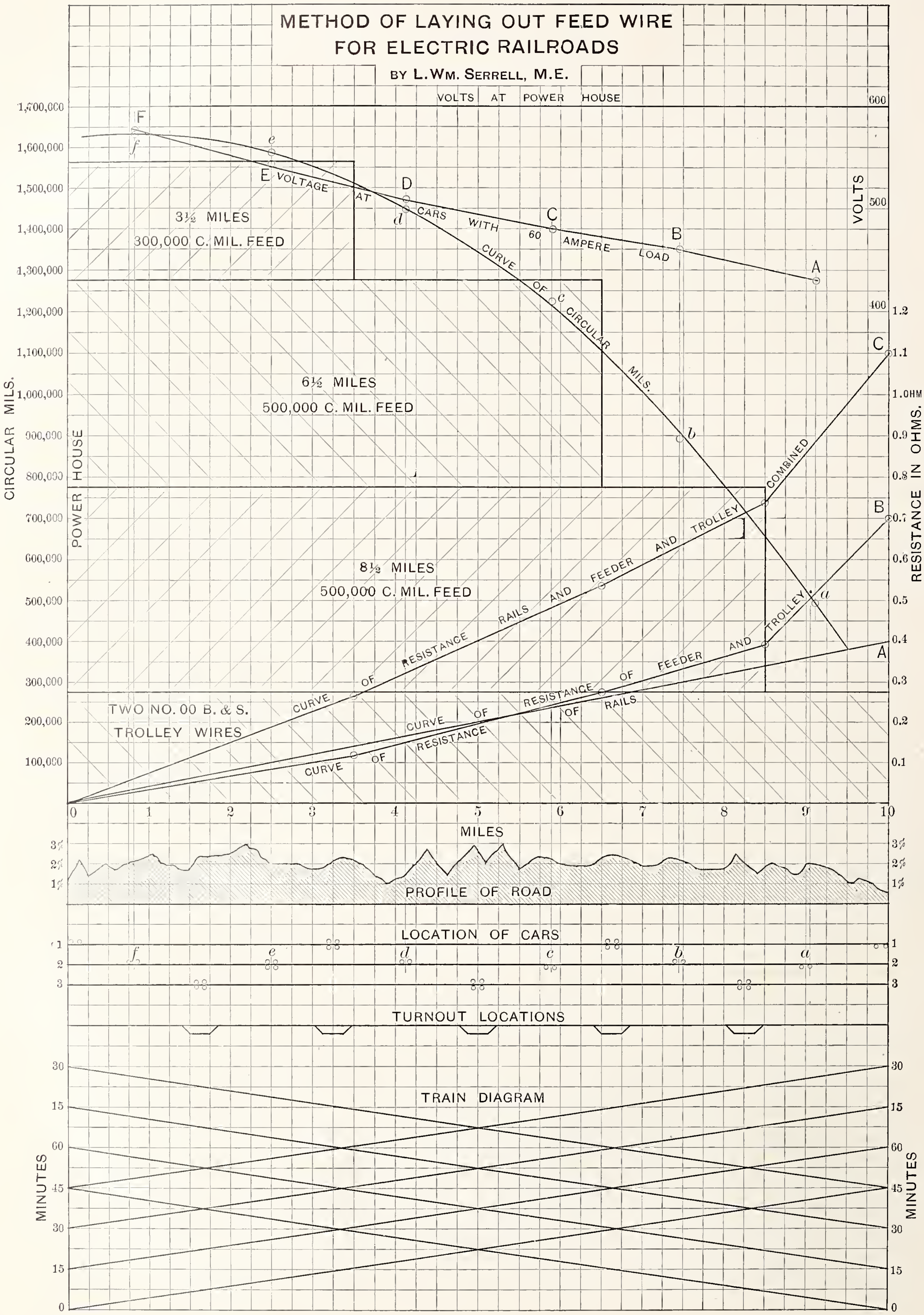
BEFORE the amount of feed wire required for the operation of an electric railroad can be accurately plotted, a careful study of the profile, headway of cars, weight of cars, number of stops, and the amount of power required to operate the cars must be determined. To do this work satisfactorily, the amount of power required to operate the cars must be determined and plotted, having in mind the stops, accelerations, effect of grades, braking, coasting, etc., from all of which the average amount of power expressed in kilowatt-hours can be determined with great accuracy before the road is built. Much has already been written on this matter, and the writer will not undertake to go over the same ground in this short article, which has reference only to a simple method of plotting the minimum amount of copper required for the operation of the cars after the average amount of power to move them has been determined.

In the case here selected, the road is 10 miles long, and is operated from a direct-current power station having 600 volts in the power house. The number of cars on the line is six, the mean speed per hour is 13.3 miles, and the grades are light, not to exceed 3 per cent, the territory being a rolling country. A determination of the amount of power required has shown that the cars will not average over 60 amperes each. The problem to be solved, therefore, is this:—How can we determine the most economical amount of feed wire that can be used to operate this road with a loss of 10 per cent in the feeder and trolley combined?

The first thing to determine is the average location of the cars upon the line. To do this, a train diagram is laid out as shown at the bottom of the chart on the next page. As the cars make the run of 10 miles in 45 minutes, and the round trip in an hour and a half, the intersection of the lines in the train diagram will give the location of the turn-outs, or the passing points of the cars in case a double track is used, the cars running every 15 minutes and passing one another every $7\frac{1}{2}$ minutes.

Three different locations of the cars are then determined,—first, when a car is at each end of the line; second, when all the cars are passing one another at the same time; third, an intermediate location when all the cars are uniformly distributed over the line. This intermediate location is the best one to use in determining the amount of feed wire.

An abscissa is laid off representing the length of the line, divided into miles; ordinates are then erected, representing circular mils. In order to figure the circular mils, the constant 54,800 is used, that is, a wire 1 mile long having a resistance of 1 ohm, will have 54,800 circular mils area. By using Ohm's law, we have $R = \dfrac{E}{C}$. As the drop in voltage allowed is 10 per cent, there would be a loss of 60 volts, and as the amount of current used is 60 amperes for each car, we would need a wire having a resistance of 1 ohm. As the location of the car *a* in the diagram is 9 miles from the power house, a wire 9 miles long having a resistance of 1 ohm would thus have to have 9 × 54,800 circular mils area, or 493,200 circular mils, in order


METHOD OF LAYING OUT FEED WIRE
FOR ELECTRIC RAILROADS
BY L. WM. SERRELL, M.E.
VOLTS AT POWER HOUSE
CIRCULAR MILS.
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
600
500
400
VOLTS
1.2
1.1
1.0 OHM
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
RESISTANCE IN OHMS.
POWER HOUSE
3½ MILES
300,000 C. MIL. FEED
6½ MILES
500,000 C. MIL. FEED
8½ MILES
500,000 C. MIL. FEED
TWO NO. 00 B. & S.
TROLLEY WIRES
VOLTAGE AT CARS WITH 60 AMPERE LOAD
CURVE OF CIRCULAR MILS.
CURVE OF RESISTANCE RAILS AND FEEDER AND TROLLEY COMBINED
CURVE OF RESISTANCE OF FEEDER AND TROLLEY
CURVE OF RESISTANCE OF RAILS
CURVE OF RESISTANCE
F
E
D
C
B
A
f
e
d
c
b
a
0
1
2
3
4
5
6
7
8
9
10
MILES
3%
2%
1%
PROFILE OF ROAD
LOCATION OF CARS
TURNOUT LOCATIONS
TRAIN DIAGRAM
30
15
60
45
0
MINUTES

to supply the car with 60 amperes at 60 volts drop. The upper point *a* is, therefore, plotted at 493,200 circular mils, as shown in the diagram.

The car *b*, operating under the same conditions, is 7.4 miles from the power house, and would, therefore, require a wire having 7.4 × 54,800 circular mils area, or 405,520 circular mils. This is added to the area already obtained for the car *a*, and gives 898,720 circular mils as the area of the wire required to supply the current for two cars. The upper point *b* is, therefore, plotted at 898,720 circular mils, as shown in the diagram.

This method of figuring is carried through for each of the cars, and the amount of wire, expressed in circular mils, required to operate each car under the conditions named is added to the previous size of the wire until the entire number of cars upon the road has been included in the calculation. The result will be a series of points *a*, *b*, *c*, *d*, *e*, and *f*, which produce the parabolic curve as shown in the diagram and entitled "Curve of Circular Mils." In other words, were it possible to have a wire whose area in circular mils at each mile and fraction of a mile distant from the power station corresponded to the area called for by this curve, the cars would all be operated under the same average loss, and the most economical amount of copper wire that could be used to produce this result would have been secured.

In practice, however, it is necessary to use the materials that the manufacturer provides, and we can only approximate this theoretical curve. This is done, first, by laying off the area in circular mils for two No. 00 B. & S. gauge trolley wires; on top of this we add 8½ miles of 500,000 circular mil feed wire, then 6½ miles of 500,000 circular mil feed wire, and then 3½ miles of 300,000 circular mil feed wire. These wires, stretched out from the power house, will approximate the theoretical area of the Curve of Circular Mils very closely.

In order to determine the voltage at the cars, with a load of 60 amperes at each car, we first lay out a curve of resistance of feeder and trolley as actually erected. This is easily done by reference to any wire tables giving resistances, and is shown by the curve $O B$. The resistance of the track is then determined, as shown by the curve $O A$. The sum of these two gives the curve $O C$, which is the resistance of the rails, feed wire and trolley combined.

It is somewhat difficult to determine the resistance of the rails, as both the composition of the rails and the method of bonding produce a variation from the theoretical resistance. It should be the endeavor of the engineer, however, to so bond the rails that the resistance at the joints will not be any greater than the resistance of the rails themselves, which is approximately eight times that of copper of the same section.

The curve entitled "Voltage at the Cars with 60-Ampere Load" is plotted as follows:—From Ohm's law we have $E = R C$. The point F for the car *f* is determined by taking the resistance from the curve $O C$ corresponding to the position of the car *f*, which would be 0.06 ohm; the total current flowing through the wire is 360 amperes; the drop, therefore, would, according to the above formula, be 21.8 volts. The point E is determined by taking the resistance from the curve $O C$ corresponding to the position of the car *e*, which is 0.18 ohm, and the resistance of the wire between the cars *e* and *f* would therefore be equal to 0.18 — 0.06 or 0.12 ohm. The current flowing through this part of the wire is 300 amperes. The drop would therefore be 36 volts for this portion of the line, and the total drop from the power station to the car *e* would be 21.8 volts + 36 volts, or 57.8 volts. This method is pursued to determine all the other points, each time dropping one car and the amount of current used by that car. The voltage at the last car, 9 miles from the power station, will be 435 volts under the average conditions of load used in this illustration.

The effect upon the line voltage when the cars are ascending heavy grades or during the acceleration of starting can all be determined and plotted in the same manner, the illustration here given having been made as simple as possible in order that its principles may be easily understood.

Electric Traction in Italy

STORAGE-battery traction has not been successful on the Italian Meridianal Railway, and the management of the road has accordingly been authorized to discontinue this electric system on certain lines, and to replace it by steam. The overhead trolley system, however, over the 90 odd miles of the standard gauge railroad along Lake Como has met all requirements.

Recently a public meeting took place at the instance of the chambers of commerce of Milan, Lecco and Chiavenna, which resolved to request the Italian Government to immediately establish the trolley system upon the lines of Lecco to Milan. The results with the electric system with a third rail over the 45 miles of the standard-gauge Milan-Varese-Porto Ceresio Railroad have been entirely satisfactory.

The traffic on this line, which connects Milan with Lake Lugano, has increased surprisingly on account of the cheaper rates, number of trains and quicker time. The management of the road is perfectly satisfied with the financial result.

The Mediterranean Railroad contemplates the extension of the electric system with a third rail over the lines Varese-Laveno-Gallarat-Sesto Calende-Arona, so that then Milan will be directly connected with the upper Italian lakes by four electric standard railroads.

Wireless Telegraphy Experiments between Germany and Sweden

THE Berliner Gesellschaft für Drahtlose Telegraphie some time ago installed two wireless telegraph stations on the Norwegian Loffoden Islands, the two points chosen being 50 kilometers apart and separated by high, continuous rocky masses, so as to oppose serious obstacles to the passage of the electric waves. In order to ascertain whether communication over distances as high as 50 kilometers would be possible with small amounts of electric energy, the stations were equipped with dry cells. It was found that the primary energy of a limited number of dry cells was insufficient, a consumption of about 200 watts being necessary to overcome the obstacles on the passage of the electric waves.

The experiments between Germany and Sweden, as contemplated for some time past, were begun on December 16, when wireless telegraph communication was secured between Oberschœnweide, near Berlin, and Karlskrona, a Swedish naval station, a distance of about 450 kilometers. The results so far obtained are said to be quite satisfactory.

The principality of Monaco, in southern France, has had an electric railroad operating on a surface-contact system since 1898. Recently, according to the "Electrical Review," permission has been secured to use a trolley system for extensions to the line, and it has been decided to convert the whole system, although the original road has given satisfaction. The power station has an output of 220 kilowatts at 500 volts, and there are six motor cars, each equipped with two motors.

The Electrical Transmission of Water Powers

By ALTON D. ADAMS

ELECTRICAL transmission has reduced the cost of water power development. Without transmission the power must be developed at a number of different points in order that there may be room enough for the buildings in which it is to be utilized. This condition necessitates relatively long canals to conduct the water to the several points where power is to be developed, and also a relatively large area of land with canal and river frontage.

With electrical transmission the power, however great, may well be developed at a single spot and on a very limited area of land. The canal in this case may be merely a short passageway from one end of a dam to a nearby power house, or may disappear entirely when the power house itself forms the dam, as is sometimes the case.

These differences between the distribution of water for power purposes and the development by water of electrical energy for transmission may be illustrated by many examples.

A typical case of the distribution of water to the points where power is wanted may be seen in the hydraulic development of the Amoskeag Manufacturing Company at Manchester, New Hampshire. This development includes a dam across the Merrimac River, and two parallel canals that follow one of its banks for about 3,400 feet down stream. By means of a stone dam and a natural fall a little beyond its toe a water head of about 48 feet is obtained at the upper end of the high level canal. Below this point there is very little drop in the bed of the river through that part of its course that is paralleled by the two canals. All of the power might thus be developed within a few rods of one end of the dam, if means were provided for its distribution to the points where it must be used.

Years ago, when this water power was developed, the electrical transmission or distribution of energy was unheard of, and distribution of the water itself had therefore to be adopted. For this purpose the two canals already mentioned were constructed along the high bank of the river at two different levels.

The high-level canal, so-called, was designed to take water directly from the basin or forebay a little below one end of the dam, so that between this canal and the river there is the full water head of about 48 feet. Over nearly its entire course the nearest side of this high-level canal runs between 450 and 750 feet from the edge of the river wall, and thus includes between it and the river a large area on which factories to be driven by water wheels may be located. It was thought, however, that this strip of land between the high-level canal and the river was too wide for the ready connection of each wheel with head and tail water, and the lower level canal was therefore constructed parallel with that on the higher level, but with about 21 feet less elevation.

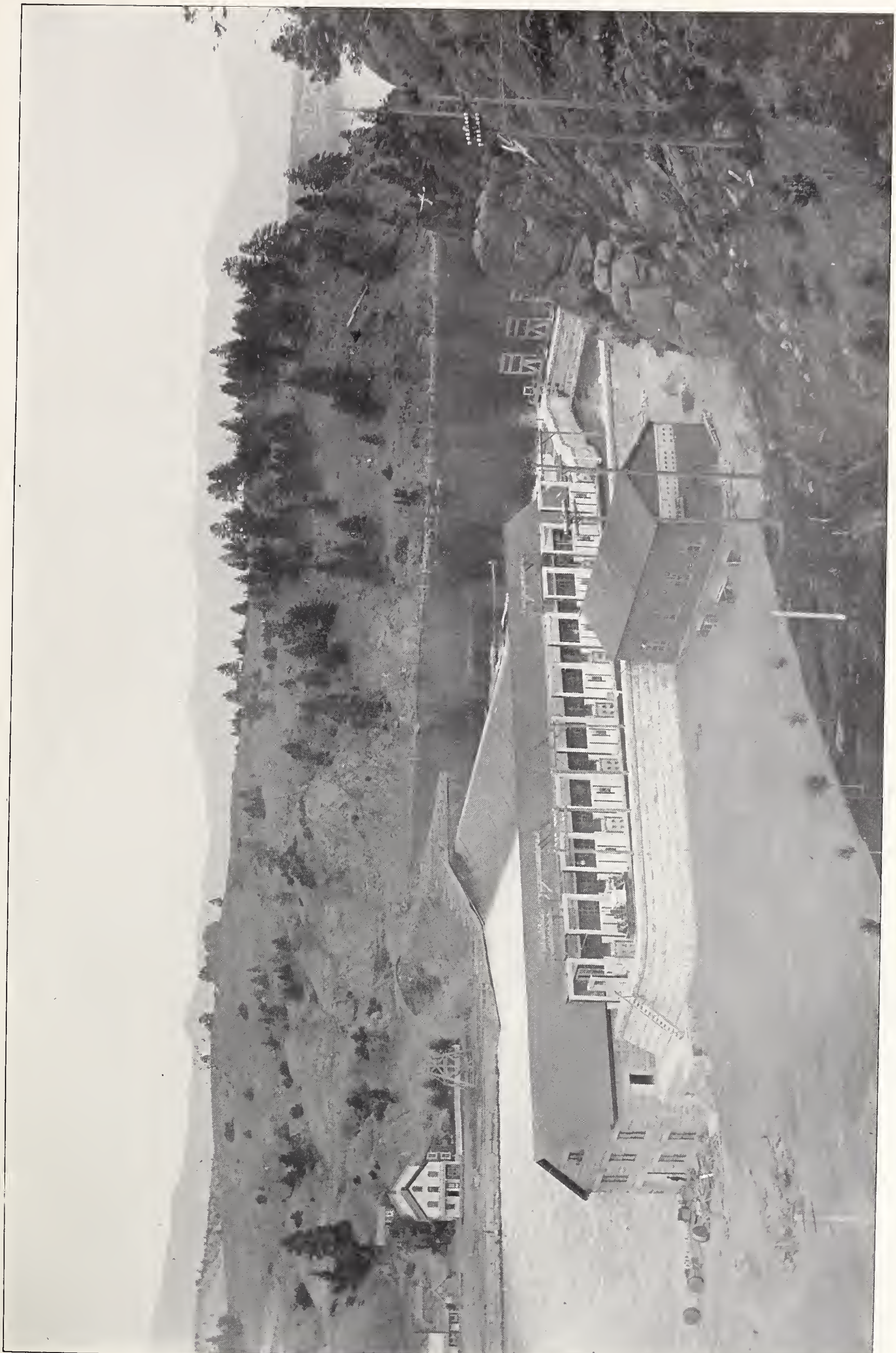
Between these two canals a strip of land about 250 feet wide was left for the location of mills. By this arrangement of canals it is possible to supply wheels located between the high and the low levels with water under a head of about 21 feet, and to supply wheels between the lower canal and the river with water under a head of about 29 feet. The entire area of land between the high canal and the river is thus made readily available for factory buildings.

Water for the lower canal is drawn mainly from the high canal through the wheels in buildings that are located between the two canals. It is desirable in a case of this sort to have as much water flow through the wheels between the high and low canal as flows through the wheels between the low canal and the river, but this is not always possible. A gate is, therefore, provided at the forebay where the two canals start, by which water may pass from the forebay directly into the low canal when necessary, but the head of 21 feet between the forebay and the low canal is lost as to this water. Between the high and low canal, and between the low canal and the river 23 turbine wheels or pairs of wheels have been connected, and these wheels have a combined rating of 9,500 horse power.

To carry out this hydraulic development it thus appears that about 1.3 miles of canal have been constructed; one-half this length of river front has been required, and about one-sixth square mile of territory has been occupied. Contrast with this result what might have been done if electrical transmission of power had been available at the time when this water power was developed. All but a few rods in length of the existing 1.3 miles of canal might have been omitted, and an electric generating station with wheels to take the entire flow of the river might have been located not far from one end of the dam. Factories utilizing the electric power thus developed might have been located at any convenient points along the river front or elsewhere, and no space would have been made unavailable because of the necessity of head and tail water connections to scattered sets of wheels.

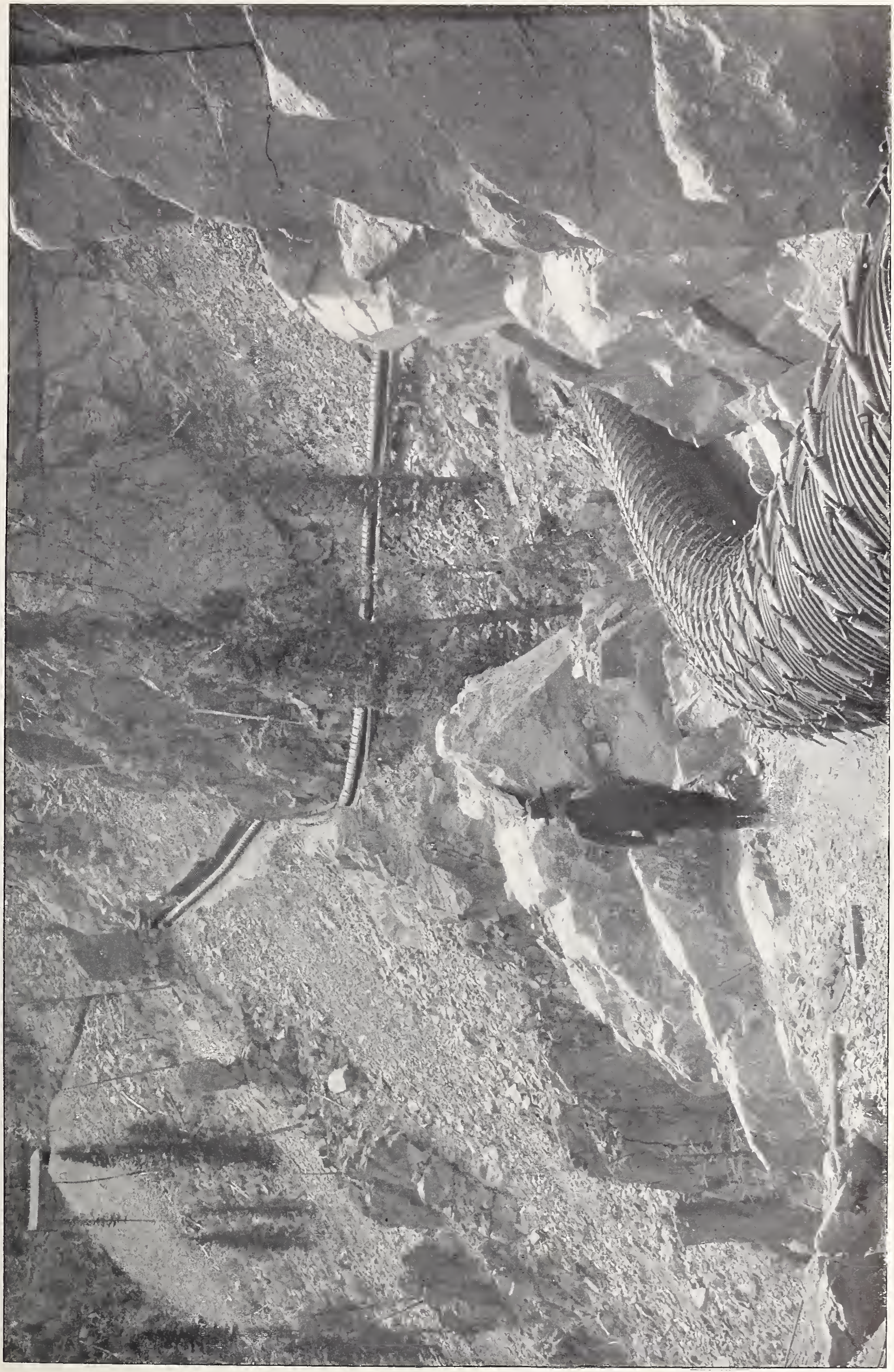
Compare with the foregoing hydraulic development that at Cañon Ferry on the Missouri River, in Montana, where 10,000 horse power is developed under a water head of 32 feet. At Cañon Ferry the power house is 225 feet by 50 feet at the floor level inside, contains turbine wheels direct connected to ten main generators of 7,500 kilowatts, or 10,000 horse power combined capacity, and is built on the river bank close to one end of the 500 foot dam. The canal which runs along the land side of the power house, and takes water at the upstream side of the abutment, is less than twice the length of the power house itself. The saving in the cost of canals construction alone, to say nothing of the saving as to the required area of land, is evidently a large item in favor of the electrical development and transmission. In its small land area and short canal the Cañon Ferry plant is not an exception, but is rather typical of a large class of electric water power plants that operate under moderate heads.

A like case may be seen in the plant at Red Bridge, on the Chicopee River, in Massachusetts, where a canal 340 feet long, together with penstocks 100



THE POWER HOUSE OF THE MISSOURI RIVER POWER COMPANY AT CANON FERRY, MONTANA. TEN THOUSAND HORSE POWER ARE HERE AVAILABLE

THE POWER HOUSE OF THE PIKE'S PEAK POWER COMPANY, TELLER COUNTY, COLORADO, SUPPLIES PRINCIPALLY THE CRIPPLE CREEK MINING INDUSTRY, THOUGH A LARGE AMOUNT OF CURRENT IS FURNISHED ALSO FOR THE LIGHTING OF VARIOUS TOWNS IN THAT LOCALITY



ALONG THE ARMORED WOODEN-STAVE PIPE LINE OF THE PIKE'S PEAK POWER COMPANY

feet long, convey water from one end of the dam and deliver it to wheels in the electric station with a head of 49 feet. This station contains electric generators with a combined capacity of 4,800 kilowatts or 6,400 horse power, and its floor area is 141 by 57 feet.

So again, at Great Falls, on the Presumpscot River, in North Gorham, Maine, the electric station rests about 40 feet in front of the forebay wall, which adjoins one abutment of the dam, and there is no canal whatever, as short penstocks bring water to the wheels with a head of 35 feet. In ground area this station is 67.5 by 55 feet, and its capacity in main generators is 2,000 kilowatts or 2,700 horse power.

A striking illustration of the extent to which electrical transmission reduces the cost of water power development may be seen at Gregg's Falls on the Piscataquog River, in New Hampshire, where an electric station of 1,200 kilowatts capacity has been built close to one end of the dam, and receives water for its wheels under a head of 51 feet through two short penstocks, each 10 feet in diameter, that pierce one of the abutments.

Perhaps the greatest electric water power station anywhere that rests close to the dam that provides the head for its wheels, is that at Spier Falls, on the upper Hudson. One end of this station is formed by the high wall section of the dam, and from this wall the length of the station downstream is 392 feet, while its width is 70 feet 10 inches, both dimensions being taken inside. The canal or forebay in this case, like that at Cañon Ferry, lies on the bank side of the power station, and is about equal to it in length. From this canal ten short penstocks, each 12 feet in diameter, will convey water under a head of 80 feet to as many sets of turbine wheels in the station. These wheels will drive ten generators with an aggregate capacity of 24,000 kilowatts or 32,000 horse power.

Sometimes the slope in the bed of a river is so gradual or so divided up between the number of small falls, or the volume of water is so small, that no very large power can be developed at any one point without the construction of a long canal. In a case of this sort electrical transmission is again available to reduce the expense of construction that will make it possible to concentrate all the power from a long stretch of the river at a single point. This is done by locating electric generating stations at as many points as may be thought desirable along the river whose energy is to be utilized, and then transmitting power from all of these stations to the single point where it is wanted.

A case in point is that of Garvins Falls and Hooksett Falls on the Merrimac River and four miles apart. At the former of these two falls the head of water is 28 feet, and at the latter it is 16 feet. To unite the power of both these falls in a single water-driven station would obviously require a canal 4 miles long whose expense might well be prohibitive. Energy from both of these falls is made available at a single sub-station in Manchester, New Hampshire, by a generating plant at both points and transmission lines thence to that city.

At Hooksett the present capacity of the electric station is 1,000 horse power, and at Garvins Falls the capacity is 1,700 horse power. The river is capable of developing larger powers at both of these falls, however, and construction is now under way at Garvins that will raise its station capacity to 5,000 horse power.

A similar result in the combination of water powers without the aid of a long canal is reached in the case of Gregg's Falls and Kelley's Falls, which are 3 miles apart on the Piscataquog River. At the former of these two falls the electric generating capacity is 1,600 horse power, as previously noted, and at the latter fall the capacity is 1,000 horse power. In each case the station is close to its dam, and no canal is required. Electrical transmission unites these two powers in the same sub-station at Manchester that receives the energy from the two stations above named on the Merrimac River.

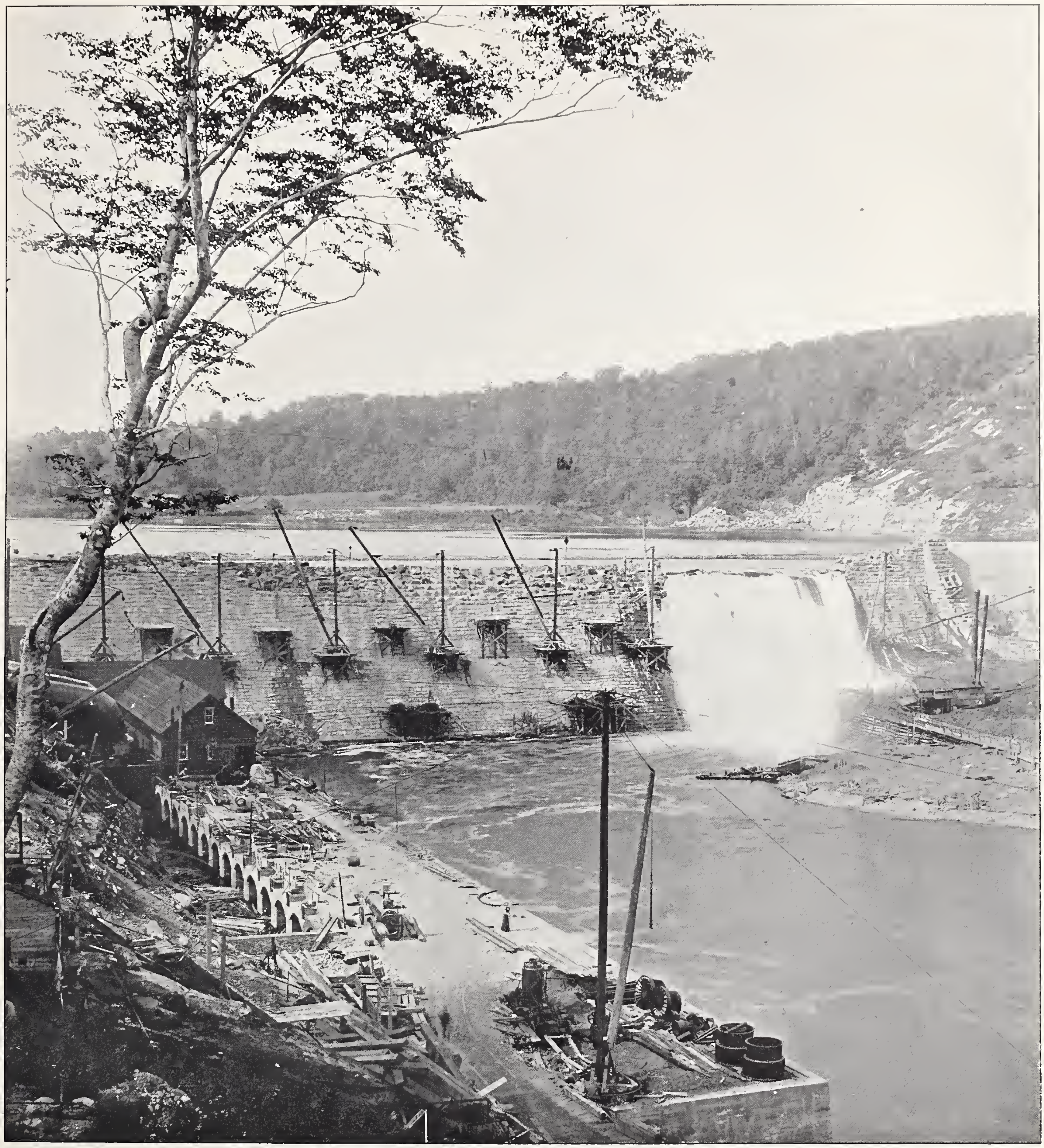
Instead of transmitting power from two or more water falls to some point distant from each of them, the power developed at one or more falls may be transmitted to the site of another and there used. This is, in fact, done at the extensive Ludlow twine mills on the Chicopee River, in Massachusetts. These mills are located at a point on the river where its fall makes about 2,500 horse power available, and this fall has been developed to its full capacity. After a capacity of 2,400 horse power in steam engines had been added, more water power was sought, and a new dam was located on the same river at a point about 4.5 miles up stream from the mills. The entire flow of the river was available at this new dam, and a canal 4.5 miles long might have been employed to carry the water down to wheels at the mills in Ludlow.

Such a canal would have meant a large investment, not only for land and construction, but also, possibly, for damages to estates bordering on the river, if all of its water was diverted. Instead of such a canal, an electric generating station was located close to the new dam with a capacity of 6,400 horse power, and this power is transmitted to motors in the mills at Ludlow.

Even where the power is to be utilized at some point distant from each of several water falls, it may be convenient to combine the power of all at one of them before transmitting it to the place of use. This is actually done in the case of two electric stations located respectively at Indian Orchard and Birchem Bend on the Chicopee River, whose energy is delivered to the sub-station of the electrical supply system in Springfield, Massachusetts. At the Indian Orchard station the head of water is 36 feet, and at Birchem Bend it is 14 feet, while the two stations are about 2 miles apart. A canal of this length might have been built to give a head of 50 feet at the site of the Birchem Bend dam, but instead of this an electric station was located near each fall, and a transmission line was built between the two stations. Each generating station was also connected with the sub-station in Springfield by an independent line, and power is now transmitted from one generating plant to the other, as desired, and the power of both may go to the sub-station over either line. In the Indian Orchard station the dynamo capacity is about 2,000 kilowatts, and at Birchem Bend it is 800 kilowatts.

Another case showing the union of two water powers by electrical transmission, where the construction of an expensive canal was avoided, is that of the electrical supply system of Hartford, Connecticut. This system draws a large part of its energy from two electric plants on the Farmington River, at points that are about 3 miles apart in the towns of Windsor and East Granby, respectively. At one of these plants the head of water is 32 feet, and at the other it is 23 feet, so that a head of 55 feet might have been obtained by building a canal 3 miles long. Each of these stations is located near its dam, and the generator capacity at one station is 1,200 and at the other 1,500 kilowatts. Transmission lines deliver power from both of these plants to the same sub-station in Hartford.

Sometimes two or more water powers on the same river that are to be united are so far apart that any attempt to construct a canal between them would be impracticable. This is illustrated by the Spier and Mechanicsville Falls on the Hudson River, which are 25 miles apart in a direct line and a greater distance by the course of the stream. At Spier

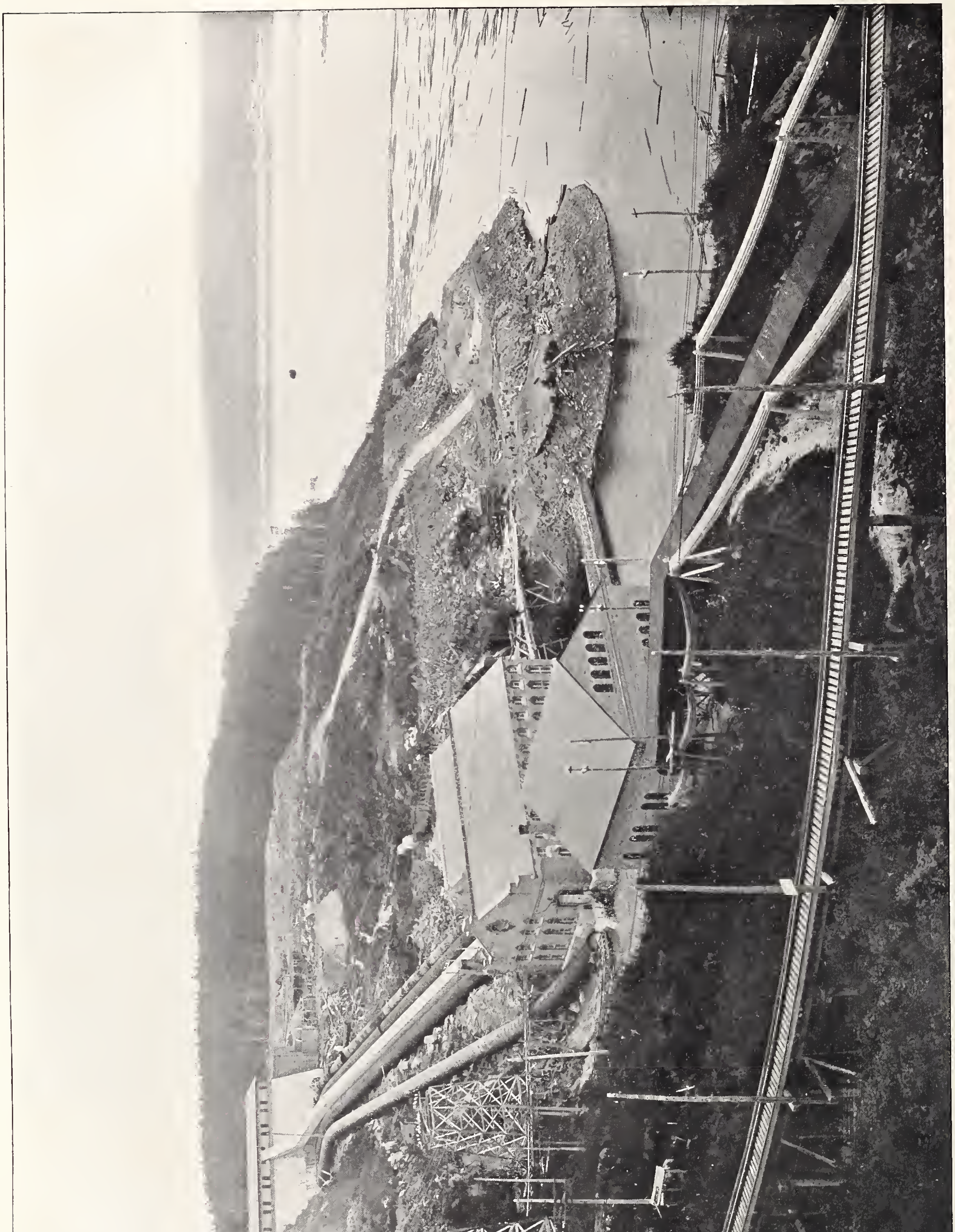


A CONSTRUCTION VIEW OF THE DAM AT SPIER FALLS, ON THE HUDSON RIVER, NEW YORK, SHOWING ALSO THE FOUNDATION, AT THE LEFT, FOR THE POWER HOUSE.

Falls the head is 80 feet, and at Mechanicsville it is 18 feet, but the bed of the river drops more than 200 feet between these two points and the general elevation of the river valley falls off accordingly. Union of the power of these two falls is thus out of the question for physical reasons alone. Electrical transmission, however, brings energy from both of these water powers to the same sub-stations in Schenectady, Albany and Troy.

In another class of cases electrical transmission does what could not be done by any system of canals, however expensive; that is, it unites the water powers of distinct and distant rivers at any desired point. Thus power from both the Merrimac and the Piscataquog rivers is distributed over the same wires in Manchester; the Yuba and the Mokelumne contribute to electrical supply along the streets of San Francisco; and the Monte Alto and Tlalnepantla yield energy in the City of Mexico.

It does not follow from the foregoing that it is always more economical to develop two or more smaller water powers at different points along a river for transmission to some common center than it is to concentrate the water at a single larger station by more elaborate hydraulic construction, and then deliver all of the energy over a single transmission line. The



A VIEW OF THE POWER HOUSE OF THE SHAWINIGAN WATER & POWER COMPANY. THE CANAL FROM THE ST. MAURICE RIVER FALLS, CANADA, ENDS ON HIGH GROUND ABOUT 125 FEET ABOVE THE POWER HOUSE. THE FALLS YIELD ABOUT 100,000 HORSE POWER

single larger hydraulic and electric plant will usually have a first cost much larger than that of the several smaller ones, because of the required canals or pipe lines. A partial offset to this larger hydraulic investment is the difference in cost between one and several transmission lines, or at least the cost of the lines that would be necessary between the several smaller stations in order to combine their energy output before its transmission over a single line to the point of use.

Against the total excess of cost for the single larger hydraulic and electrical plant there should be set the greater expense of operation at several smaller and separate plants. Even a small water-driven electric station that can be operated by a single attendant at any one time must have two attendants if it is to deliver energy during the greater part or all of every 24 hours. But a single attendant can care for a water power plant of 1,000 to 2,000 horse power capacity, so that two plants of 750 horse power each will require double the operating force of one plant of 1,500 horse power. If two such plants are constructed instead of one that has their combined capacity, the monthly wages of the two additional operators required by the two plants will amount to at least one hundred dollars. If money is worth 6 per cent. yearly, it follows that an additional investment of $\$1,200 \div 0.06 = \$20,000$ might be made in hydraulic work to concentrate the power at one point before the annual interest charge would equal the increase of wages made necessary by two plants.

Reliability of operation is one of the most important requirements in an electric water-power plant, and its construction should be carried out with this in view. Anchor ice is a serious menace to the regular operation of water wheels in cold climates, because it clogs up the openings in the racks and in the wheel passages. Anchor ice is formed in small particles in the water of shallow and fast flowing streams, and tends to form into masses on solid substances with which the water comes in contact.

At the entrance to penstocks or wheel chambers, steel racks with long, narrow openings, say 1¼ inches wide, are regularly placed to keep all floating objects away from the wheels. When water bearing fine anchor or frazil ice comes in contact with these racks, it rapidly clogs up the narrow openings between the bars, unless men are kept at work raking off the ice as it forms. At the Niagara Falls electric station, in some instances when the racks become clogged, they have been lifted, and the anchor ice allowed to pass down through the wheels. This is said to have proved an effective remedy, but it would obviously be of no avail in a case where the ice clogged the passages of the wheels themselves.

The best safeguard against anchor ice is a large, deep forebay next to the racks, where the water being comparatively quiet, will soon freeze over after cold weather commences. The anchor ice coming down to this forebay and losing most of its forward motion, soon rises to the surface or to the under side of the top coating of solid ice, and the warmer water sinks to the bottom. Good construction puts the entrance ends of penstocks well below the surface of water in the forebay, so that they may receive the warmer water that contains little or no anchor ice.

Illustrations of practice along these lines as to size, depth of forebay and location of penstocks may be seen in many well designed plants. One instance is that at Garvins Falls, on the Merrimac river, where the new hydraulic development for 5,000 horse power is now under way. Water from the river in this case comes down to the power station through a canal 500 feet long, and of 68 feet average width midway between the bottom and the normal flow line. In depth up to this flow line the canal is 12 feet at its upper and 13 feet at its lower end, just before it widens into the forebay. In this forebay the depth increases to 17 feet, and the width at the rack is double that of the canal. The steel penstocks, each 12 feet in diameter, terminate in the forebay wall at an average distance of 7 feet behind the rack, and each penstock has its center 10.6 feet below the water level in the forebay. As there is a large pond created by the dam in this case, and as the flow of water in the canal is deep rather than swift, enough opportunity is afforded to any anchor ice to rise to the surface before it reaches the forebay in this case.

Penstocks for the electric station at Great Falls, on the Presumpscot River, whence energy is drawn for lighting and power in Portland, Me., are each 8 feet in diameter, and pierce the forebay wall behind the rack with their centers 15 feet below the normal water level in the forebay. In front of the forebay wall the water stands 27 feet deep, and the pond formed by the dam, of which the forebay wall forms one section, is 1,000 feet wide and very quiet. Though the Maine climate is very cold in winter and the Presumpscot is a turbulent stream above the dam and pond, there has never been any trouble with anchor ice at the Great Falls plant. An excellent illustration is thus presented of the fact that deep, still water in the forebay is a complete remedy for troubles with ice of this sort.

Maximum loads on electrical supply systems are usually from twice to four times as great as the average loads during each 24 hours. A pure lighting service means the larger ratio between the average and maximum load, while a larger motor capacity along with the lamps, tends to reduce the ratio. Furthermore, by far the greater part of the energy output of an electrical supply system during each 24 hours must be delivered between noon and midnight. For these reasons there must be enough water stored, that can flow to the station as wanted, to carry a large share of the load during each day, unless storage batteries are employed to absorb energy at times of light load, if the entire normal flow of the river is to be utilized.

It is usually much cheaper to store water than electrical energy for the daily fluctuations of load, and the only practicable place for this storage is more commonly behind the dam that maintains the head for the power station. This storage space should be so large that the drain upon it during the hours of heavy load will lower the head of water on the wheels but little, else it may be impossible to maintain the standard speed of revolution for the wheels and generators, and consequently the transmission voltage.

At the Great Falls plant, water storage to provide for the fluctuations of load in different parts of the day takes place back of the dam, and for about one mile up-stream. This dam is 450 feet long in its main part, and a dike wall increases the total length to about 1,000 feet. For half a mile upstream from this dike and dam the average width of the pond is 1,000 feet, and its greatest depth is not less than 27 feet. As the station capacity is 2,700 horse-power in main generators, with a head of 35 feet at the wheels the storage capacity is more than ample for all changes of load at different times of day.

The dam at Spier Falls, on the Hudson River, is 1,820 feet long between banks, 155 feet high above bedrock in its deepest section, and raises the river 50 feet above its former level. Behind the dam a lake is formed one-third of a mile wide and 5 miles long. Water from this storage reservoir passes down through the turbines with a head of 80 feet, and is to develop 32,000 horse-power. As a little calculation will show, this lake is ample to maintain the head under any fluctu-

POWER HOUSE NO. 2 OF THE NIAGARA FALLS POWER COMPANY

ation in the daily load. At Cañon Ferry, where electrical energy for Butte and Helena, Montana, is developed, the dam, which is 480 feet long, crosses the river in a narrow canyon that extends up-stream for about half a mile. Above this canyon the river valley widens out, and the dam, which maintains a head of 30 feet at the power station, sets back the water in this valley, and thus forms a lake between two and three miles wide, and about seven miles long. At the station the generator equipment has a total rating of 10,000 horse power. From these figures it may be seen that the storage lake would be able to maintain nearly the normal head of water for some hours, when the station was operating under full load, however small the flow of the river above.

According to reports, the Russian Post Office has been experimenting with automobiles to replace horses in conveying the mails to and from railway stations. Fourteen automobiles have been ordered by the St. Petersburg Post Office, ten of these are of large size, for carrying mails to the trains, while the four smaller ones will be used in collecting letters from the post boxes in the streets.

Niagara Power Plant Extensions

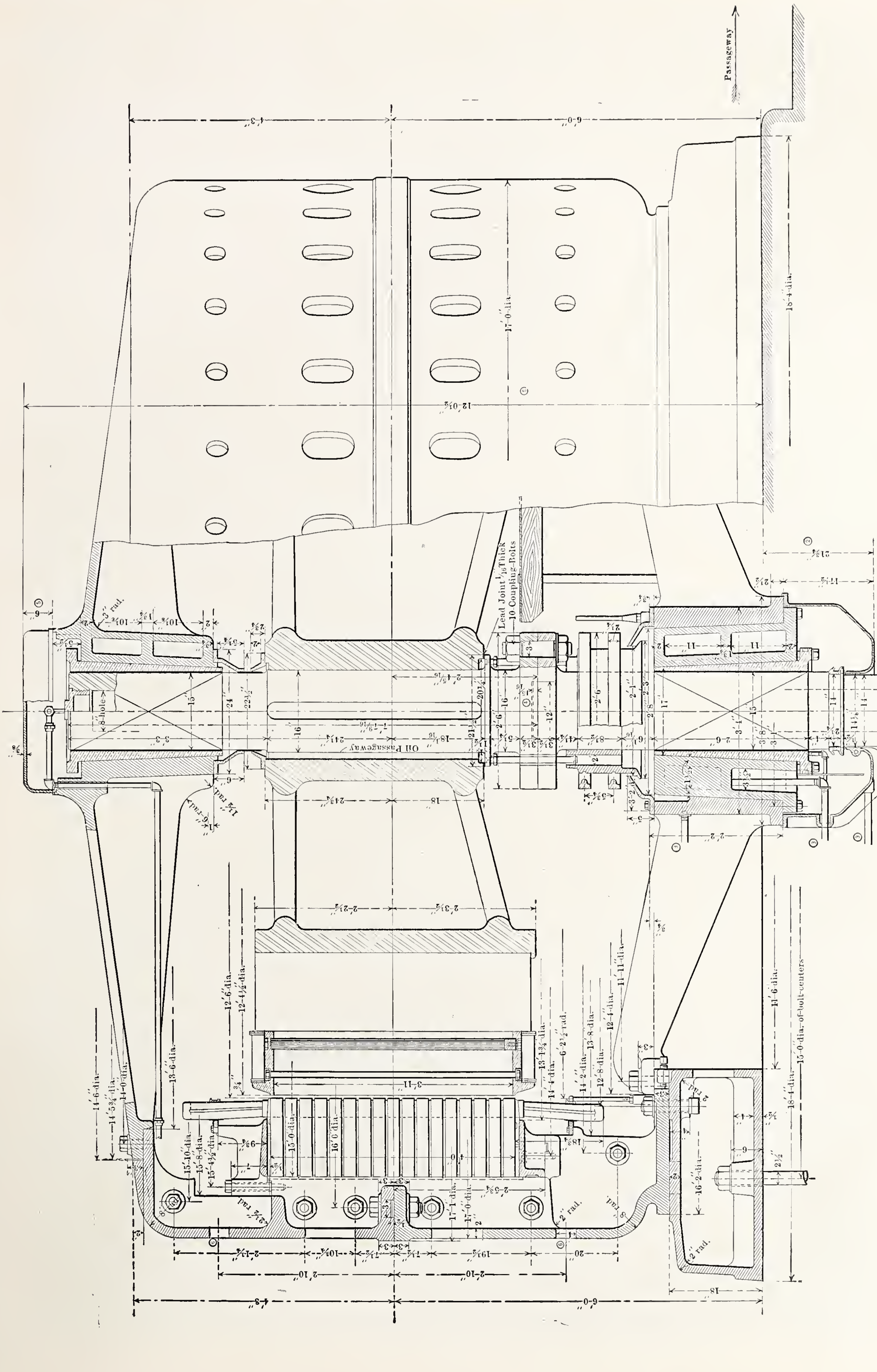
By H. W. BUCK, Electrical Engineer of the Niagara Falls Power Co.

PROBABLY no better measure could be offered of the great success, commercial and engineering, of the Niagara Falls Power Company's operations than the statement that, at the present time, the limit of the capacity of the company's second power house has almost been reached, and a third power house is now being erected on the Canadian side of the Niagara River.

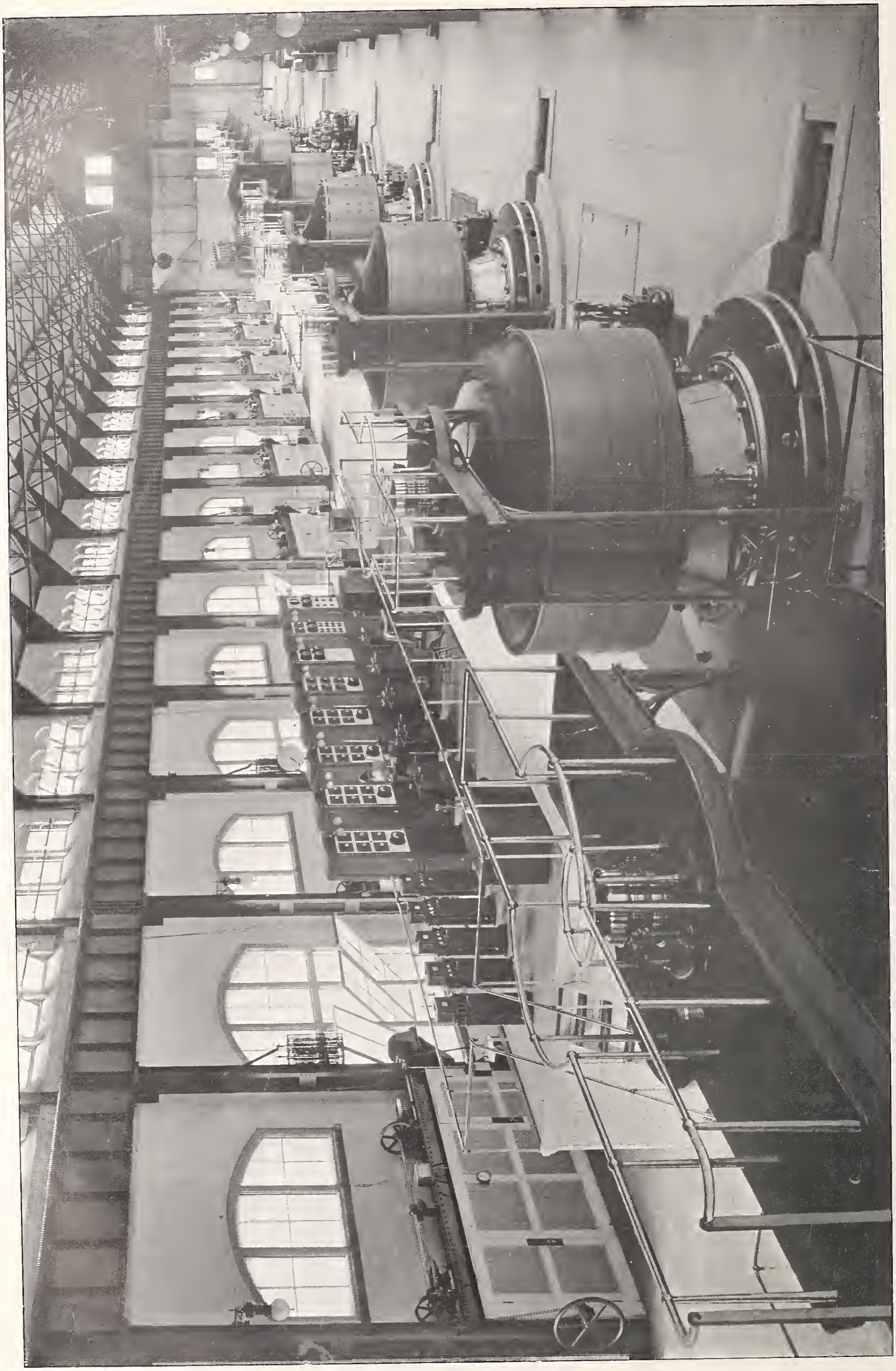
The first power house, with which the company began operations in 1895, has a capacity of 50,000 horse power, disposed of in ten generators of 5,000 horse power each. The second plant, on the American side, known as Power House No. 2, is located near the first power house, but on the opposite side of the inlet canal, and its equipment consists of eleven 5,000 horse power generators, six of them of the same type as those in Power House No. 1, with external revolving fields, and the remaining five with internal revolving fields and outside stationary armatures. This type was decided upon on account of the much lower cost of building, simplicity of handling, and accessibility to the various parts, as compared with the external field design; but, like the original machines, the later ones are wound for 2,200 volts, 25 cycles, two phase, and run at a speed of 250 revolutions per minute.

The Canadian plant, now approaching completion, will be operated by the Canadian Niagara Power Company, a Canadian corporation controlled by the Niagara Falls Power Company. This plant, with a capacity, when completed, of 110,000 horse power, is located in Queen Victoria Park, about 1,500 feet above the Horse Shoe Falls. Its hydraulic feature will be similar to that of the American plants, with its intake canal, wheel pit, and discharge tunnel leading to the foot of the Horse Shoe Falls. This power development will be used for the transmission of power to Toronto and other Canadian cities within transmission distance, and for the distribution of power to factories located in Canada in the neighborhood of the power house. It will also be used for the supply of power to the American power system, with which it will be arranged to operate in parallel.

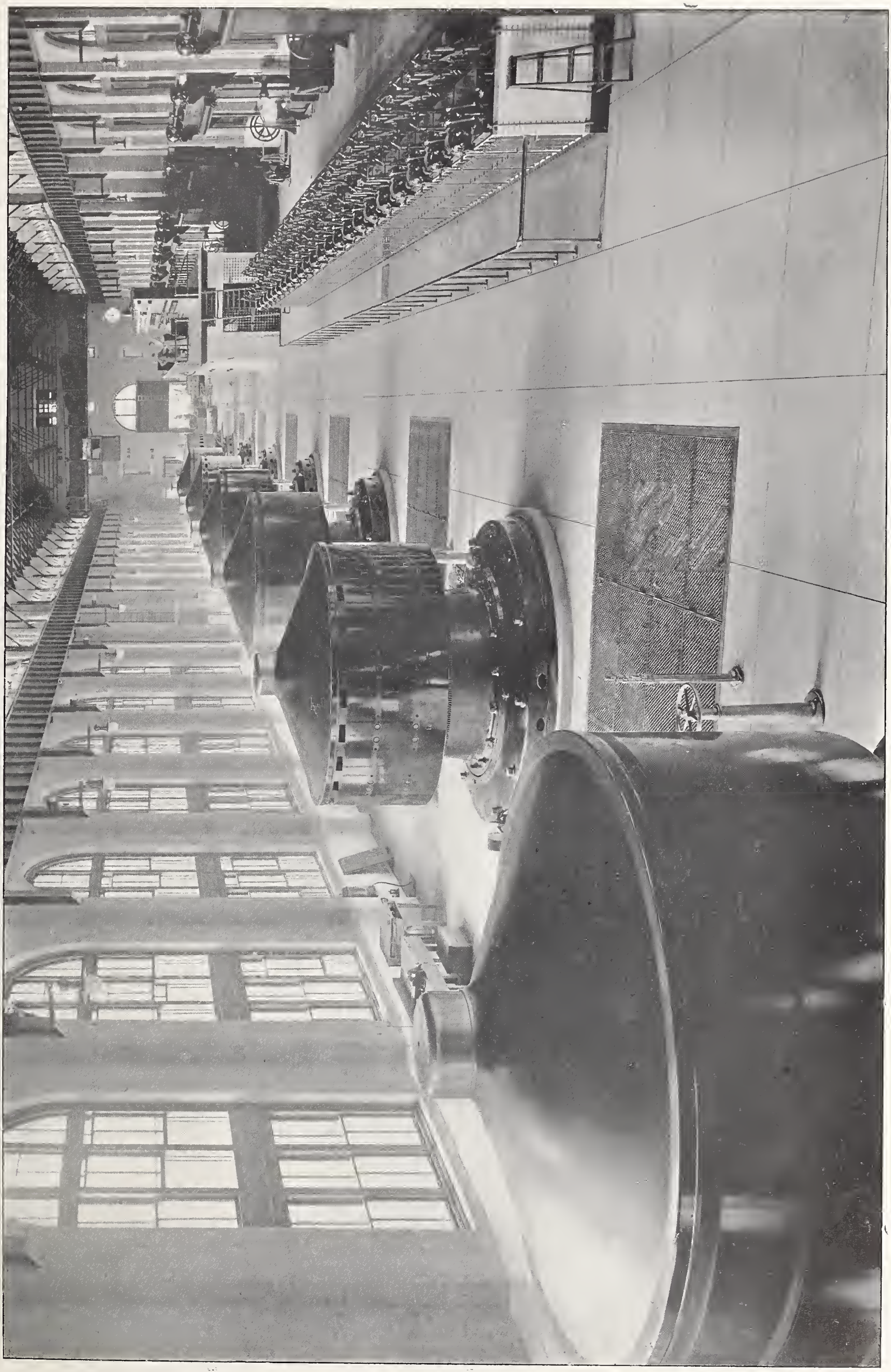
The essential differences embodied



SECTION AND ELEVATION OF ONE OF THE 10,000 H. P. GENERATORS FOR THE CANADIAN NIAGARA POWER COMPANY



NIAGARA POWER HOUSE NO. 1 CONTAINS TEN GENERATORS OF THE EXTERNAL REVOLVING FIELD TYPE, OF 5,000 H. P. EACH



POWER HOUSE NO. 2. ELEVEN GENERATORS OF 5,000 H. P. EACH. FIVE OF THESE GENERATORS ARE OF THE INTERNAL REVOLVING FIELD TYPE, SHOWN IN SECTION AND ELEVATION ON PAGE 51.

in this plant will be in the size of unit and in the electrical arrangements. The unit will be of 10,000 horse power capacity (7,500 kilowatts), and the generators will be wound for 11,000 volts three-phase. The frequency will be retained at 25 cycles for the sake of uniformity with the American plants, so as to permit of parallel operation. In selecting this size of unit the American and Canadian systems were regarded as one. Since this is likely to ultimately reach an output of several hundred thousand horse power, a unit of 10,000 horse power is not a large proportion of the whole, and is not too large an amount of power to concentrate in one machine from the standpoint of convenience.

The principal advantage of a unit of this size over the smaller one is in the reduction in cost of development per horse power. This reduction in cost results from,—

1. Lower cost of generator per horse power.

2. Lower cost of turbines per horse power.

3. A 10,000 horse-power unit occupies only slightly more space than one of 5,000 horse-power capacity, which results, for a given plant output, in great reduction in length of wheel pit, power house and forebay, and a consequent reduction in construction.

Other advantages will result, such as simplicity of operation—owing to the reduction in the number of units—and reduction in the cost of maintenance. This size of unit was suggested by the engineers of the Niagara Falls Power Company, and was adopted upon their recommendation. The generators, five of which have been ordered, are being constructed by the General Electric Company.

One of them is shown in assembly on page 51. It is of the internal revolving field vertical shaft type, like the later generators in Power House No. 2. Its revolving field ring is built up of punched laminations, bolted together with joints lapped. This method of construction gives a uniform and definite strength of ring and high magnetic permeability. The weight of the revolving part of the machine is 141,000 pounds, with a fly-wheel effect, at 250 revolutions per minute, of 2,000,000,000.

The high tension of 11,000 volts was selected, not for long-distance transmission, but for economy in distribution to power users near the power house. In distributing large amounts of power underground from a 2,200-volt, two-phase plant, as in the case of power houses Nos. 1 and 2, after a radius of about one mile is exceeded, it becomes cheaper to transform to 12,000 volts three-phase, and distribute at this voltage, than to supply power directly at 2,200 volts. From this it becomes evident that great economy results from the direct generation of the higher voltage. For long-distance transmission, step-up transformers will be used to raise the voltage to 22,000, 40,000, or 60,000 volts.

The new plant is expected to be in operation by July 1, 1904. Its output will be used for Canadian industries in the province of Ontario within transmission distance of the power house, or for American consumers, as the demand may be. A part of its output may be sent to Buffalo by a transmission line to be built on the Canadian side of the Niagara River.

The Niagara power system now covers a very large territory; thousands of people are dependent upon it in their daily lives, and commercial interests of great importance are involved in it. The industrial world has learned that the Niagara power enterprise is no longer an experiment, and that it has already become an important factor in the manufacturing status of this continent. Its extent and the great variety of the industries which it operates will be seen from the list which follows:—

NIAGARA POWER SYSTEM. LIST OF CUSTOMERS

NIAGARA FALLS, N. Y.	Maximum Power Used	Distance From Power House
Name	H.P.	Miles
The Pittsburg Reduction Co.	8,000	0.46
The Carborundum Company	5,000	0.38
Union Carbide Company	15,000	2
Niagara Electro-Chemical Company	2,000	0.75
Niagara Falls Lighting Company	1,000	0.14
International Railway Company	1,500	..
The Niagara Falls Water Works Company, hydraulic power	300	..
International Paper Company, hydraulic power	8,000	..
Castner Electrolytic Alkali Company	7,000	0.85
Niagara Development Company	100	1.23
Oldbury Electro-Chemical Company	1,500	2.18
Electrical Lead Reduction Company	500	0.19
International Acheson Graphite Co.	1,000	0.28
The United Barium Company	2,000	0.66
Acetyvone Manufacturing Company	50	0.95
Roberts Chemical Company	500	1.90
Francis Hook & Eye & Fastener Co.	15	0.47
Norton Emery Wheel Co.	650	0.95
The Natural Food Company	1,500	0.66
Ramapo Iron Works	500	1.70
By-Products Paper Company	500	0.19
Composite Board Company	200	0.34
Atmospheric Products Company	50	0.47
Niagara Research Laboratories	500	0.28
NIAGARA FALLS, ONTARIO		
A. C. Douglass, contractor	400	3
M. P. Davis, contractor	300	3.7
A. C. Jenckes, contractor	200	3.5
The Carborundum Company	200	3.6
Niagara, St. Catharines & Toronto Ry.	500	3.8
Lighting Company	300	3.4
TONAWANDA		
International Railway Company	1,500	..
Tonawanda Board & Paper Company	1,200	15
Buffalo Bolt Company	160	14
Philip Houck Milling Company	142	14
F. J. Alliger Company	107	15
Adamite Abrasive Company	50	14.5
Orient Manufacturing Company	20	14
Felton School	22	14
LOCKPORT		
Lockport Lighting Company	500	25
International Railway Company	1,000	26
OLCOTT		
International Railway Company	1,000	39

BUFFALO	Maximum Power Used	Distance From Power House
Name	H.P	Miles
Buffalo Railway Company	7,000	27
Buffalo General Electric Company	6,000	27.6
The Charles G. Curtiss Company	125	25.5
McKinnon Dash Company	100	24.4
Pratt & Letchworth	233	24.5
W. W. Oliver Manufacturing Company	15	24.7
Acme Steel & Malleable Iron Works	50	24.8
N. Y. Car Wheel Works	200	24.3
National Battery Company	90	26.3
Standard Plaster Company	100	25.5
Great Northern Elevator Company	900	29.5
Buffalo Dry Dock Company	133	30
Electric Grain Elevator	200	30.7
Barcalo & Boll Manufacturing Co.	60	30
Schoellkopf & Co.	50	30
Iron Elevator & Transfer Company	165	30
Great Eastern Elevator	900	30
Sidney Shepard & Co.	100	30
J. I. Prentiss & Co.	30	29
Edward Elsworth & Co.	150	30
American Agricultural Chemical Co.	125	32
Jacob Dold Packing Company	100	32.5
Empire Bridge Company	90	33
Buffalo Elevating Company	950	29
John Kam Malting Company	225	24.3
American Brake Shoe & Foundry Co.	40	33.2
Buffalo Cereal Company	375	30.3
Taylor Signal Company	65	25.5
Snow Steam Pump Works	150	33.3
Wood & Brooks Company	100	24.4
U. S. Rubber Reclaiming Works	995	31.7
American Radiator Company	200	24
Cumpson-Prentiss Coffee Company	30	29.1
Duffy Brothers & Nellis	50	33.5
Buffalo Foundry Company	240	35.1
H. O. Mills	255	29.3
Jewett Manufacturing Company	30	24.8
Buffalo Pitts Company	187	35.5
Buffalo Brake Beam Company	30	25
Buffalo Dental Manufacturing Co.	20	35.5
Keystone Manufacturing Company	25	24.8
R. L. Ginsburgh & Sons	33	34
Buffalo Weaving & Belting Company.	65	25.5
H. W. Dopp & Co.	10	25
Frontier Iron Works	15	25
The Crosby Company	50	33
Lackawanna Steel Company	70	29.4
West Manufacturing Company	40	28
Buffalo Gasoline Motor Works	20	25
Pratt & Lambert	10	24.5
Wagner Machine Company	40	29
Spencer Kellogg Company	500	29.2
Hygienic Food Company	300	32.3
Collins Baking Company	50	33.2
George Urban Milling Company	450	34.5
Niagara Mill & Elevator Company	100	26
D., L. & W. R. R. Shops	150	34.5
Ryder Belt & Cordage Company	65	24.7
United States Headlight Company	40	26
George E. Laverack Building	100	28.2
Buffalo Structural Steel Company	30	26
J. N. Adam & Co.	100	28.2
Genesee Hotel	100	28.1

The figures given are for maximum power used in each case. Since the maximum in the various plants does not occur at the same time, the resultant maximum at the power house is somewhat less than their sum. At present it amounts to about 75,000 estimated H. P.

At the present time, 4000 women are employed in the telephone service of the German Empire. In Berlin alone, 1000 women are engaged. These positions are so popular that the number of accepted and qualified women whose names have been registered in the order in which they were considered is so large as to supply occupants for any possible vacancies that may result in the course of the next few years. Only physically strong girls are admitted to the service. They must possess a good character and be of respectable families. They must be between 18 and 30 years of age, either unmarried girls or widows without children.

Electrolytic Decomposition of Underground Metals

Causes, Effects, and Remedies

By A. A. KNUDSON, E. E.

THE depreciation of valuable underground metals due to corrosion caused by electric railway currents, commonly termed electrolysis, continues to demand the serious attention of those responsible for the safety of such properties. Such concern is but natural, for whenever a cause is continuous we must expect the effect to be also continuous.

In this case, under the single-trolley system with its "ground" return, a continuous condition is created which makes the effect—electrolysis—unavoidable, as it happens to come under the well-established law of divided circuits. There are, however, many different phases of electrolytic action upon underground metals, which are governed entirely by local conditions prevailing in each city, town, or suburban district. Some of these phases and effects will be mentioned later.

Depreciation in underground metals, caused by electrolysis, cannot be previously estimated upon a percentage basis, as is now done with steam plants and other machinery, as it is practically impossible to determine the full extent of damage to mains or other metals in a given time, owing to the greatly varying conditions. In the case of cable anchorages of suspension bridges, for instance, which cannot be examined, no exact knowledge of the extent of electrolytic action upon them can be obtained, although voltmeter measurements indicate that they are being damaged.

It is true that appraisements of damage by electrolysis to a city's water mains or to a gas company's mains are often made, but to arrive at a fair estimate the mains must be uncovered at a number of places and carefully examined, and even then many points of damage may be undiscovered, such as those under asphalt or brick pavements which it is not desirable to disturb. This silent destroyer of subjacent metal structures has practically a free rein among them twenty-four hours a day, in varying force according as the electric cars are used by the traveling public. This point is worthy of further attention.

It has been found by electrical measurements upon water and gas mains, taken every few minutes through the twenty-four hours, that the current flow through such mains corresponds exactly with the varying power station load, in the rise and fall of strength at the same periods of the twenty-four hours; for instance, the highest peaks of current strength on a main are usually found during the so-called rush hours of travel in a big city, between 5 and 8 a. m., or between 5 and 7 p. m., when the cars are heavily loaded. During the night and small hours of the morning this current falls off to a very small degree; the same changes of load at the electric railway power houses occur at exactly these same periods of time.

This fact is mentioned to show the complete identification of the source of current in underground mains, and also as illustrating how closely the law of divided circuits is followed under the single-trolley method of operating electric cars.

The varying strength of railway current flowing in a water or gas main is therefore governed by the current output from a power house, while the amount of such current is largely governed by the condition of the track circuit. For instance, in the case of heavy rails, double-bonded at the joints, with auxiliary feeders, a much smaller proportion of current will escape to mains than in the case of light rails with few or no bonds, and no auxiliaries.

While the former case is, of course, more preferable than the latter, it is no guarantee of immunity from electrolysis, for, as a rule, both of these conditions prevail in the same city or town, the better construction being placed in the busy streets, and the distant points or suburbs being usually left with anything that may do. There are many lines operating to-day upon tracks that are not only unbonded, but have neither line nor return feeders. In such cases differences of potential between tracks and mains run as high as 25, 30, or 50 volts, indicating the entry of considerable current into the mains.

The worst case of such track conditions discovered by the writer was where the maximum readings reached 140 volts. As a result, the water main and the gas main in the street were found to be carrying practically all of the return current used by the single

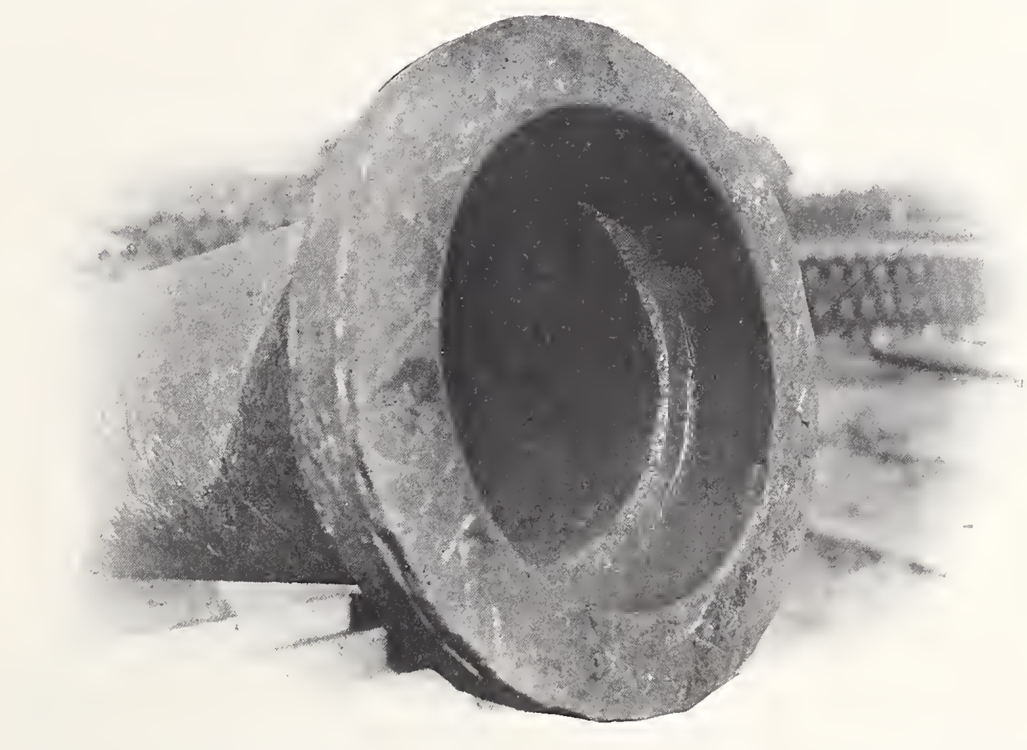


FIG. 1.—A CORRODED PIPE END. THE INNER EDGE OF THE HUB WAS SO SOFTENED THAT IT COULD BE CUT WITH A PEN-KNIFE

car which passed over the line. This, however, is an exceptional case, but it shows an inclination to neglect the distant points in railway construction, when such points should have just as much attention, if any consideration

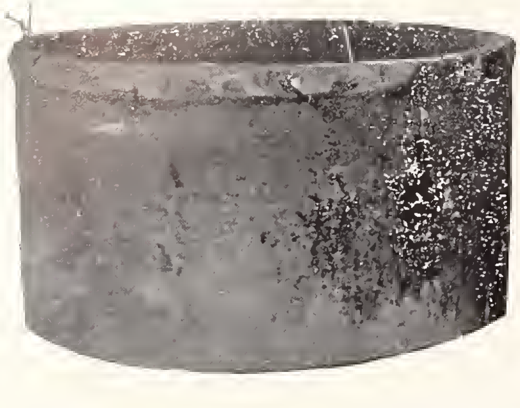


FIG. 2.—THE SOFTENED CONDITION OF THIS PIPE END IS SHOWN BY THE NAILS DRIVEN INTO IT

is given to the preservation of underground mains from electrolysis, as those in the more central parts of a city, for it is at these distant points that most of the current enters which is found in the mains.

Various metal structures other than underground pipes which may lie in the path of the trolley current are affected by electrolysis, such as bridges, gas holders, subway structures, water meters, and others. In cases where the action is severe and rapid, unless discovered by investigation, the result is usually announced by the fracture of service pipes, a water or gas main, or by the giving way of lead-covered underground electric cables. But the bursting of water mains is not the only result to be feared; the effect of electrolysis upon a large part of a piping system, such as the slower action at the joints, is also a serious matter. Each joint in a water or gas main has a certain electrical resistance, and a current in passing through a main encounters one of these resistances about every twelve feet, the result being a more or less pronounced eating-away of the metal at some of them from the side where the current leaves, due to shunting through the damp soil, or through the water inside in the case of a water main.

This process is slower than in cases where the current passes out of a main at right angles. In the latter case the destructive effect is generally localized in one or more spots or furrows and the main is punctured; joint corrosion, however, is important, as it means a shortening of the life of a large part of a piping system and is responsible for many leaks, the damage being proportional to the mileage of the mains, which depends, of course, on the size of the city.

Figs. 2 and 3 are reproductions from photographs of a 16-inch main, and very well illustrate the effect of trolley current passing lengthwise through the main and its action at the joints. This main was taken up owing to a change in pumping stations, a new one having been built. When removed from the ground, it was discovered that every joint in the 1,000-foot length taken out was more or less damaged at the spigot side only, the flow of current being in the direction from spigot to bell. The softened condition of the iron caused by electrolysis, to a depth of an inch, is shown by the nails driven into it. Fig. 1 shows the effect where the current flow was in the reverse direction, namely, from bell to spigot. In this case, the inside edge of the hub was softened and was cut away with a penknife. The outside edge was also affected in a number of places. In some instances, in order to prevent

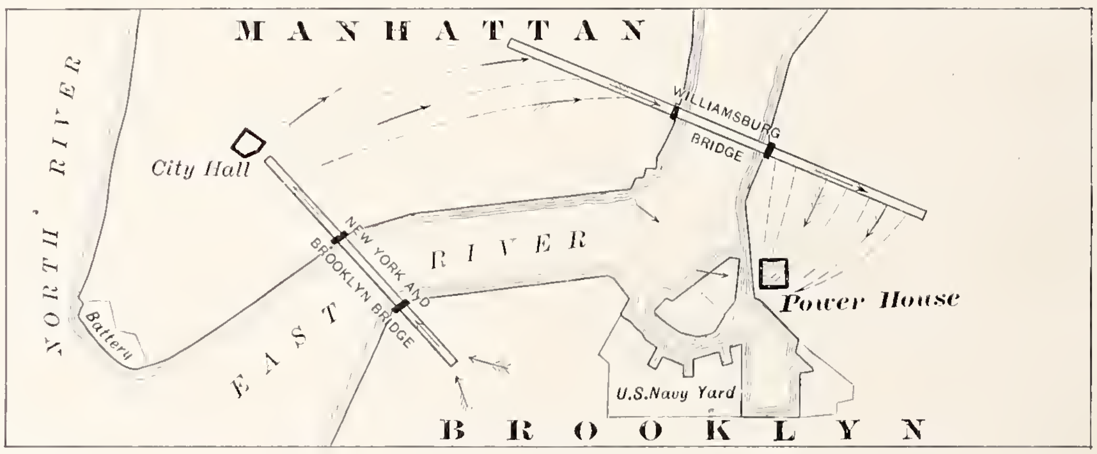


FIG. 4.—DIAGRAM SHOWING THE PATH OF TROLLEY CURRENTS FROM BROOKLYN TO MANHATTAN AND BACK AGAIN BY WAY OF THE TWO EAST RIVER BRIDGES

electrolysis at certain locations upon mains, they have been connected by copper wires or cables to the tracks, or track returns. This largely increases the flow of current through mains, and joint damage is increased in proportion.

A French writer on the subject of electrolysis, speaking of this plan of connecting mains with track returns,

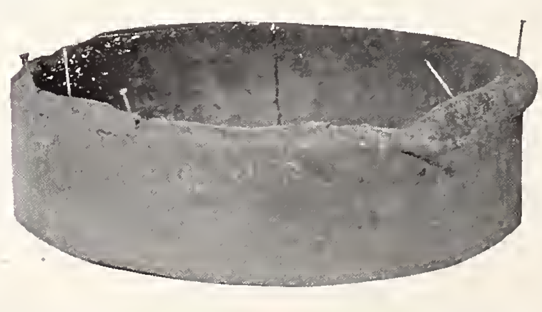


FIG. 3.—ANOTHER PIPE END SAMPLE, SIMILAR TO THE ONE SHOWN IN FIG. 2

says "that such a method should be legally forbidden," and then he names the same reasons which have here been given. Past experiences as well as recent discoveries lead to the conviction that such a method is wrong in principle and certainly disastrous to pipes in the long run.

In tracing the flow of trolley currents through underground mains and ascertaining points of exit of such currents—the points where the damage occurs—many interesting cases are found. In one case damage was suspected on a 48-inch steel force main connecting a pumping station with a reservoir, the main passing about 8 miles through the country and furnishing the sole water supply for a city. At a point about half-way between the pumping station and the reservoir a single-track suburban trolley road crossed over the pipe line. Fig. 5 shows the position of the power house of the trolley line, the pumping station and reservoir, with the distances between each. Arrows show the direction of flow of the returning current on this and other mains.

The tracks were only partly bonded, and there were no auxiliary feeders. A portion of the return current passed along the main near the town, beginning near the dead end at *F.*, thence flowing south (the power house is north) to a 36-inch distributing main, thence west to the reservoir, and to the steel main, thence easterly to where the main crossed under the trolley road, and there most of it was discovered coming out under the tracks at *E.*

The measurements on the steel main west of the crossing resulted in finding the maximum flow of current, 19.2 amperes, and east of the crossing, 6.25 amperes, leaving 13 amperes to be accounted for. Voltmeter tests indicated this current coming out of the main under the crossing. The main was uncovered and the results are fairly given in Fig. 6. The top and sides of the main were quite badly affected by electrolysis. The bottom could not be examined. This route of the trolley current and the damage discovered will give some idea of what

usually happens at other places where the conditions are similar.

Probably the most important section of the city of New York where electrolysis can do more harm to underground metals than at other places, is in the vicinity of the two large suspension bridges across the East River. This is shown in Fig. 4. In this sketch the direction of returning railway currents from one of the Brooklyn railways is shown by arrows, and it will be seen that they cross over to Manhattan by way of the older bridge, then travel along by mains, subways, and other media back to Brooklyn by way of the new bridge, then again enter various underground mains in Brooklyn and finally again reach the power house. Before the new bridge was commenced, these currents returned to Brooklyn through the river bed, the larger portion near the section opposite the power house. Some, however, spread considerably further north before again crossing the river.

Recently a current measurement was obtained by the writer upon a 6-inch pipe on the Brooklyn side of the new bridge in connection with the structure, and a flow of nearly 70 amperes was found coming over from the Manhattan side, passing directly into the mains in Brooklyn on the way to the power house. This pipe,

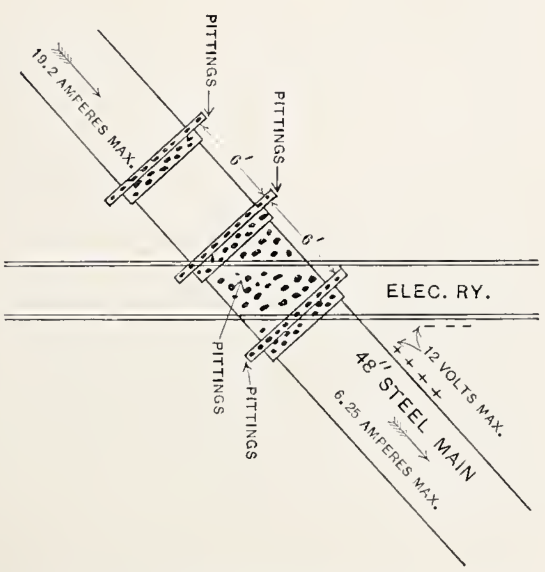


FIG. 6.—A DETAIL OF FIG 5, SHOWING EFFECTS OF ELECTROLYSIS

however, is but one of several paths the current may take, and must represent only a small proportion of the entire amount; much existing underground ironwork in connection with the soil becomes convenient for collecting this current in Manhattan, its delivery in Brooklyn being by substantially the same means. It is at these points of delivery that the danger lies, as it is only where the current leaves a metal and passes through soil or water that electrolysis takes place. Such danger areas are at the Manhattan side of the old Brooklyn Bridge, and the Brooklyn side of the new or so-called Williamsburg Bridge. The Brooklyn power house, shown in Fig. 4, known as the Kent Avenue power house, therefore, is responsible for a large amount of electricity that is straying through the underground mains and other metals in large sections of both

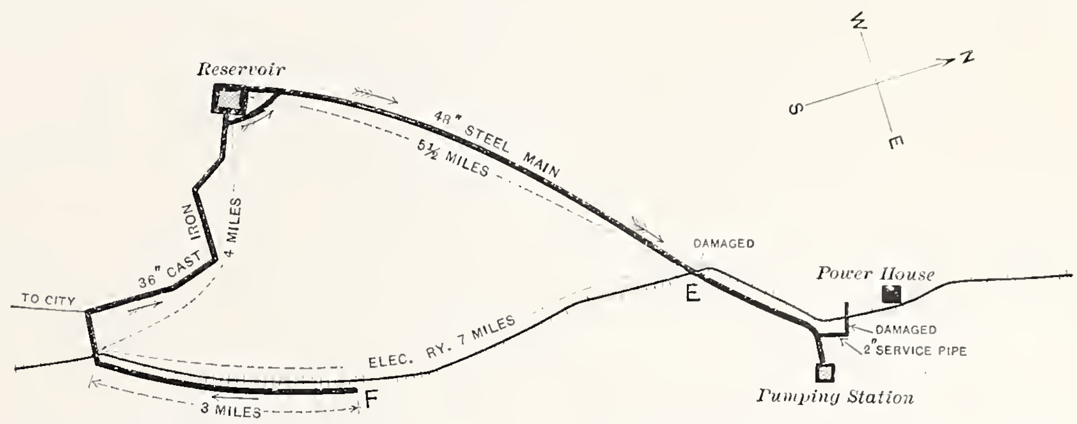


FIG. 5.—DIAGRAM OF A SUBURBAN TROLLEY LINE, SHOWING THE PATH OF THE RETURN CURRENT ALONG WATER PIPES

New York and Brooklyn, and the effect of the stray currents has often been shown in the destruction of water and gas mains in its vicinity, such as at the United States Navy Yard and in other places.

These items of information were gleaned from examinations made by the writer that were largely superficial, and by no means represent all that is going on in regard to electrolysis in this part of the city. These areas, however, are by no means the only ones where damage to underground metals is to be feared, though they are, no doubt, the most important in view of the costly structures located within their limits.

The Borough of Manhattan has been, up to this time, practically free from electrolysis. This is owing to the underground double-trolley system of the New York electric street car lines, as in the slotted conduit both conductors are insulated. The elevated roads are, as is well known, operated by the third-rail system. The other rails upon which the cars run carry the return, but the metal structure itself is used as an auxiliary by being bonded to the rails every 100 feet and the sections of the structure are also bonded together. This, of course, means a connection with the ground, as every pillar is grounded, and the opportunity exists for more or less straying of currents into other metals. It is probable, however, that owing to the low resistance of the mass of metal composing the elevated structure, but little diversion of the current into underground mains will take place.

The only overhead single-trolley system operating on Manhattan Isl- is through 135th Street to the Eighth Avenue terminus. A survey made by the writer in 1897 disclosed the fact that currents from that line were passing into and through underground metals for over a mile above and below 135th Street.

At present it is proposed to convert the West Street horse car line, running along one of the river fronts in New York, into an overhead single-trolley line, instead of using the "open conduit" system, because of the interference with such a system by the floods to which West Street is periodically subjected. Should this be done and the line be operated from the present power house on the East River, we may look for the return currents passing through underground metals across the island from west to east, through a large part of the city. The double overhead trolley would avoid this.

After this brief review of the subject, it may naturally be asked, what is the remedy for electrolysis? This question is practically answered at the beginning of this article, where it was endeavored to show that with the operation of single-trolley roads no complete remedy is possible. Such a remedy is to be expected only from some other system of operation which has no connection with the ground, such as the conduit system so successfully used in Manhattan, or the double overhead trolley, which is in use in some places.

Suit has been brought by the city of Alexandria, Ind., against the Indiana Traction Company for damages claimed to have been caused to the city water mains by electrolysis communicated from the wires of the traction company. If the suit succeeds it is stated that the gas company and private individuals whose supply pipes have been damaged from the same cause will also bring suit.

Interurban Electric Traction Systems

Alternating Current Versus Direct Current

By PAUL M. LINCOLN

Mr. Lincoln's admirable discussion of the points of difference between the alternating-current and the direct-current railway systems was presented first before the Electrical Section of the Canadian Society of Civil Engineers, and, while subsequently printed in several of the electrical publications, the reproduction of it in the following pages is the only entirely correct one which has thus far appeared, having been specially revised for THE ELECTRICAL AGE by the author, who has further contributed to it some supplementary remarks. Probably the most interesting part of the paper is that giving the direct comparison of first costs in an assumed case, the system being considered equipped, in one instance, with alternating-current motors, and in the other, with direct-current motors.—The Editor.

ELECTRIC traction is peculiarly an American institution; that is, it has found its widest application in American communities and has been developed chiefly by American engineers. In America, practically every town of over 5000 inhabitants is provided with an electric traction system. In other parts of the world only the larger centers of population are so provided.

Practically all the traction work in America has been done by direct current. The alternating-current traction system, although it has received considerable attention from American engineers, has not until recently been favorably thought of by them. In Europe, on the other hand, the alternating-current traction problem has received much attention. The polyphase induction motor has been developed by European engineers for traction purposes, and a number of installations have been made in Europe with apparatus of this character. American engineers have consistently refused to adopt the polyphase induction motor for traction purposes on the ground that it is not suitable for these purposes. The principal reasons for this stand are two in number:—

1.—That the polyphase induction motor is inherently a constant-speed motor and therefore not adapted to traction purposes. Continual change of speed is one of the characteristics of traction work. The direct-current series motor is peculiarly adapted to this class of work because it is inherently a variable-speed motor. At one definite speed the polyphase motor is an efficient machine, while at all other speeds the efficiency can not be greater than the ratio of the actual speed to the synchronous speed. For instance, if the actual speed at which a given induction motor is working is 10 per cent. of its synchronous speed, the power utilized is at most only 10 per cent. of the power put in. In traction work a large part of the work done is necessarily at speeds below the maximum attained and at these lower speeds the maximum economy that can be obtained from induction motors is necessarily small.

One expedient used by European engineers to reduce this source of loss is the use of motors in concatenation or in tandem; that is, the secondary of one motor is fed into the primary of another on the same car. If the pair of motors thus concatenated are wound for the same number of poles, this expedient has the effect of making the synchronous speed of each of the pair of motors one-half that which it is when not in concatenation. It is equivalent in direct-current practice to throwing two shunt motors in series.

Up to the half-speed point, therefore, there is a gain of economy by this arrangement. By winding the two concatenated motors for different numbers of poles, more than one point of maximum economy can be secured between zero speed and full speed, but this arrangement has the disadvantage of being able to use but one-half the total motor capacity above half speed, while the greatest expenditure of energy takes place above half speed.

In order to secure the advantages of concatenation, however, it is necessary to add largely to the weight of the electrical apparatus. European practice has been to equip cars with four motors, two main motors and two others which are used only while the car is below half speed. Above half-speed the motors are running idle, doing no useful work. The energy required to take care of the additional weight is an offset against the energy which is saved by concatenating the motors. For long runs this expedient would probably be detrimental, since the energy taken up to transport the extra weight would be more than equivalent to the energy saved at the start.

2.—The second reason against the use of polyphase induction motors for traction purposes is the necessity for providing at least two overhead conductors. If the track is not used as one of the conductors, then the necessity arises of using at least three overhead conductors. Maintenance of insulation on such overhead conductors when they are at high voltage is naturally a difficult problem, much more difficult than to maintain the insulation between a single conductor and ground, as would be the case in the single-phase system.

American engineers, instead of endeavoring to adapt the unsuitable induction motor to traction purposes, have devoted their energies to the development of a suitable alternating current motor. The idea of using a series motor operated by alternating-current is not new. The only alternating-current single-phase motors which have a characteristic suitable for electric traction purposes are those of the commutator type. In no other type of motor are the speed and torque characteristics such as to be suitable for traction purposes. In the commutator type alternating-current motor the speed and torque characteristics are practically identical with the corresponding characteristics in the direct-current series motor.

As early as 1893, extensive experiments were made by the Westinghouse Electric & Mfg. Co. on this class of motors. In fact, the experiments went so far as to equip a car with two motors of this type and the car was put into actual operation. Moreover, the frequency and voltage for which the motors were designed were practically the same as those for which the more recent motors were designed. These early motors were considerably smaller in capacity, however, and the trolley voltage was less. Further, the method of controlling the speed was by control of voltage.

Although the early motors were successful as motors, the alternating-current system as a system was not

thought at that time of sufficient importance to continue the developments along this line. In other words, the time was not yet ripe for the development of this system. Interurban electric traction work, such as exists to-day was not at that time thought of, and this is, in the writer's opinion, the peculiar field for the alternating-current traction system.

In considering the general problem of electric traction, the question naturally arises,—what is gained by the use of alternating current over direct current? And the converse of this question also naturally arises,—what is it necessary to sacrifice in order to obtain the benefit of alternating-current traction? An analysis of the advantages and disadvantages of these two systems may be of interest. Although many of the following points have been treated in previous papers, particularly in that of Mr. B. G. Lamme before the American Institute of Electrical Engineers, in September, 1903, it is hoped that the reader will bear with a repetition of some of the points mentioned.

The principal advantages of the alternating-current electric traction over the direct-current are,—

1.—Limits to trolley voltage are removed.

2.—Avoidance of rheostatic losses.

3.—No necessity for rotary converter sub-stations.

4.—Manual attendance at the sub-stations done away with.

5.—Danger of electrolysis by return current avoided.

Let us take up these points more in detail:—

1.—Voltage Limit Removed.—The greatest item of cost in the electrical equipment of interurban traction systems as they exist to-day is that of secondary distribution. This item of cost usually varies somewhere between 25 per cent. and 50 per cent. of the total for electrical equipment, and is usually much nearer the latter than the former. Six hundred volts at the motor in a direct-current traction system are practically the limit at which present designers and manufacturers are willing to guarantee their operation except in some special cases. This necessarily limits the voltage fed into the secondary distribution system to, say, 700 as a maximum. The consequence of this comparatively low voltage is naturally a high cost for conductors of this secondary distribution. The alternating-current system, providing, as it does, the possibility of greatly increasing the voltage of the distributing system, thus largely cuts down the cost of the latter.

Another point to which attention should here be called and which militates against the use of direct current is the fact that when large units are used, it is difficult to collect the large amount of current for their operation. For this reason, as well as because of lower cost, trolley construction has been largely replaced by the third rail for interurban work. By raising the voltage of the secondary system, the current taken by a locomotive may be reduced and consequently the difficulty with collecting devices may be made to disappear.

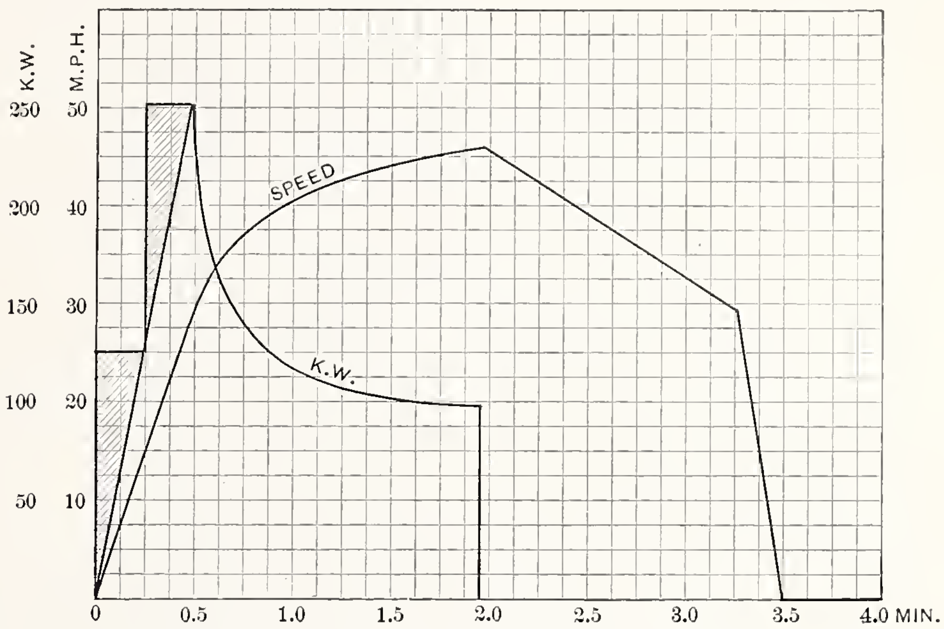


FIG. 1.—TYPICAL RUN-CURVES FOR A CAR EQUIPPED WITH DIRECT-CURRENT MOTORS

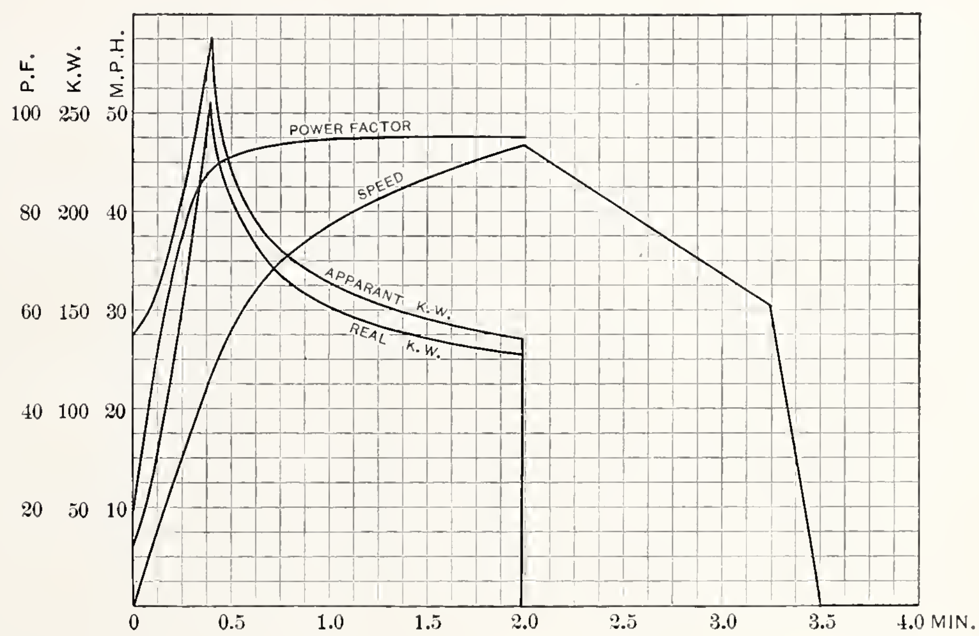


FIG. 2.—RUN-CURVES FOR A CAR EQUIPPED WITH ALTERNATING-CURRENT MOTORS

2.—Rheostatic Losses Avoided.—In the direct-current system the voltage at the car is practically constant, and while the counter E. M. F. of the motors is building up, the excess voltage must be taken up by resistance. At the start, therefore, a comparatively large rheostatic loss occurs. With the alternating-current system, on the other hand, the voltage at the car may be controlled by suitable means and the rheostatic loss thus avoided. When stops are few and consequently runs are long, the rheostatic loss in the direct-current system is a small proportion of the total, and therefore under these conditions this advantage of the alternating-current system is not so greatly marked. With short runs, on the other hand, and, consequently, frequent starts, the rheostatic loss with the direct-current system amounts to a considerably greater proportion of the total loss, and the alternating-current system therefore has the greater advantage.

Figs. 1 and 2 show K. W. curves for a car equipped in one case with direct-current motors and in the other with alternating-current motors. The weight of the direct-current car is 35 tons and that of the alternating-current car is about 18 per cent. greater. The length of run is two miles in each case, and the schedule speed 30 miles per hour. Were it not for the saving of rheostatic loss one would expect that the alternating-current equipment, being 18 per cent. heavier, would take

18 per cent. more power. The actual difference in the areas under the curves, however, shows about 10 per cent. more power in the alternating current than the direct current, on account of avoiding rheostatic loss in the alternating-current equipment. If the run were for about one mile instead of two miles, the consumption of power would be about equal, and for runs of less than one mile the alternating current power consumption would be less.

3.—Necessity for Rotary Converters Avoided.—The cost of sub-station equipment constitutes one of the large items in the cost of the electrical equipment of an interurban road. In this sub-station equipment by far the largest item of cost is the rotary converters. In the alternating-current equipment the rotary converter has no place, thus avoiding not only a large item of cost, but also one of the largest items of the loss of power.

4. — Attendance at Sub-Stations Done Away With.—The direct-current rotary being a piece of revolving machinery, of course requires manual attendance at the various sub-stations. Alternating-current sub-stations consist of static transformers only, and therefore require attendance only for the purpose of operating the switches. Making the switching devices entirely automatic in their operation avoids the necessity of attendance for this purpose. A still further refinement is the use of distant controlled switches operated from a central point, say the main power house. Electrically operated switches have already been developed, to be operated from a distance of several hundred feet, and no reason exists why this distance of operation cannot be extended to 20 or 30 miles by proper design. By including in such a switch-operating mechanism also a signalling device, by which the position of the switch is made known at the central point, the switch-operating system becomes complete and no necessity exists for attendance at the alternating-current sub-stations for any purpose except occasional inspection. There is, of course, an expense in connection with installing such a system of operating switches electrically, but it bears no comparison to the expense of manual attendance.

5. — Electrolysis. — Electrolysis of parallel conducting systems is generally recognized as one of the most serious dangers in connection with present direct-current trolley systems, and the fact that an alternating-current system avoids this danger entirely need only be mentioned in order to be recognized as a marked advantage.

So much for the advantages which accrue to the alternating-current system. Now the question arises,—what points must be sacrificed in order to obtain these advantages? The disadvantages which necessarily accompany the use of the alternating-current traction system are:—

1.—Additional weight.

2.—Difficulty of operating on existing lines.

3.—Increased rail loss.

4.—The fact that an active E. M. F. exists between field turns.

5.—Possible interference with telephones.

The writer will take up the above points in detail.

1.—Additional Weight.—An alternating-current motor of a given capacity is necessarily somewhat heavier and somewhat more expensive than a direct-current motor for the same capacity. This difference in the motor, however, does not constitute the total difference in weights of equipment. In order to make use of the advantages of high trolley voltage the alternating current equipment should preferably be provided with a step-down transformer on the car. Also, in order to obtain the advantages of avoiding the rheostatic losses, some provision must be made for controlling the voltage on the car. The transformer, the voltage control apparatus, and the greater weight of motors make the alternating-current equipment necessarily heavier than the direct current. Although this difference need not, and in many cases will not, be as great as in the example already cited (18 per cent.), still a difference in weight will always exist and will be detrimental to the alternating-current equipment. This greater weight of the alternating-current equipment is one of the items on the debit side of the ledger.

One of the most attractive methods for controlling the voltage on the motors is the use of an induction regulator. The principal advantage over other forms is that it does not require the interruption of the current and is, therefore, of particular advantage in large equipments. It is this problem of breaking the current that forms not only the greatest difficulty with direct-current equipments of large capacity but also one of the largest items in the deterioration account.

The induction regulator, however, has the disadvantage of adding considerably to the weight, and, in equipments of comparatively small size, where the difficulty of current interruption is not great, it will probably be replaced by some other method of voltage control, such as loops or commutated coils on the step-down car transformers.

2.—Difficulty of Operating on Existing Lines.—Practically all interurban roads run in and through cities on existing tracks, and therefore must use the existing sources of direct-current power. In order to meet this condition the equipment for an alternating-current interurban road must be so arranged as to operate on alternating-current outside the city and on direct-current inside. Although this is entirely possible, it must necessarily prove to be a matter of considerable complication.

It means, in the first place, the use of motors which can be operated from both direct and alternating current. This is entirely possible with the series alternating-current motor. It means, in the second place, that another system of control must be added to the car. This objection might, in part, be avoided by using rheostatic control for both the alternating-current and direct-current conditions, but there would be the objection that this method would deprive the alternating-current system of its advantages of saving rheostatic losses.

Further, means will have to be provided for disconnecting all transformers when running from the direct-current system and reconnecting them when running from the alternating-current system. All these things, although they mean a considerable amount of complication, can be accomplished. The most important part of the equipment,—the motors—can be operated from direct as well as alternating current.

3.—Increased Rail Loss.—Experiments have shown that with alternating current of 2000 to 3000 alternations, the actual loss which takes place with a given current through the iron rails is from three to five times that which the same direct current would give. The higher ratios of loss hold for the higher frequencies. At first thought this seems to be an important objection to the alternating-current system. But when it is considered that in order to utilize the main benefit of the alternating current, a higher trolley voltage is used and, therefore, smaller currents in the return conductor, the element of rail loss in an alternating-current proposition may be made even a smaller proportion of the total than in the direct current, in spite of this apparently large handicap. The rail loss with direct current is usually a small proportion of the total and this with alternating current, at the trolley voltages which are usually considered, namely, 2000 to 5000, becomes a much smaller proportion.

4.—Active E. M. F. Between Field Turns.—The space that can be assigned to the motor for operating a car is necessarily limited. It is this limitation of space, in fact, which often

forces the use of a four-motor equipment instead of a two-motor equipment, the available space not being large enough to allow the installation of large enough motors to make two of them sufficient for the work. When we consider the alternating-current motor the question of space available becomes still more exacting, first because the alternating-current motor is necessarily heavier and therefore occupies more space than an equivalent direct-current motor; and, second, because of the active E. M. F. that exists between the field turns in the alternating-current motor, and which, other things being equal, again requires additional space for insulation.

In the matter of E. M. F. between field turns, the alternating-current and direct-current motors are quite different. The E. M. F. between the field turns of a direct-current motor is due simply to ohmic resistance, and a short circuit between turns simply throws out of action the truns so short-circuited, and, if not too severe, does not interfere seriously with the motor's operation.

Between the field turns of the alternating-current motor, on the other hand, there is an active E. M. F. similar to that between the turns of a transformer winding. A short-circuit between field turns in an alternating-current motor, therefore, means a destructive short circuit and an immediate interruption of service from that motor. In other words, the effect of a short-circuit between field turns in an alternating-current motor has the same effect that a short-circuit between armature turns would have in either the alternating-current or direct-current motors.

Roasting out of field coils is one of the most frequent causes of trouble in direct-current motor equipments, and it is readily realized that this matter of active E. M. F. between field turns in the alternating-current motor is a serious one. As an offset against this disadvantage of an active E. M. F. between field turns, the alternating-current motor possesses the advantage of being capable of operation at low voltage, thereby reducing the number of turns on the series field and increasing the proportionate space for insulation. The use of a step-down transformer on the car makes available any desired voltage at the motor. This existence of an active E. M. F. between field turns is the most serious obstacle to the use of a high voltage on the motor. Even with low voltage, the alternating-current motor is laboring against the handicap of occupying more space than an equivalent direct-current motor, and the use of high voltage still further increases this handicap. The limitations of space do not apply to the transformer in anything like the same degree that they do to the motor, and no particular difficulty is anticipated in building a transformer for this work.

This limitation of available space for the motor and the existence of an active E. M. F. between field turns makes it seem probable to the writer that the alternating-current railway motor of the future will be operated at low voltage and will receive its current from a transformer situated on the car.

5.—Interference with Telephones.—It is a question whether alternating current in the rails will interfere with telephones and similar instruments more than the direct current, with which they have to contend at present. In any event, the amount of current in the rails can be reduced by the use of higher voltages so that this source of interference can be made less than it is with the present direct-current system. Further, means have been proposed whereby the current can be confined entirely to separate conductors provided for the purpose and not allowed to wander at will through any return circuit that may exist, as is the case with the direct-current system. This can be done, of course, only at the expense of erecting a separate system for the return currents and a system of series transformers whereby these currents can be confined to this return system. The alternating-current system therefore possesses the advantage of being able to use the rails for contact and still not allowing the alternating currents to escape at will through the earth. As a matter of fact, interference with other circuits by the alternating-current system is expected to be less than with the present direct-current system.

The engineer has been defined as a man who could do for one dollar what any fool could do for two. The engineer, in other words, stands for efficiency. It is he who accomplishes a given result with a minimum expenditure of effort and money. Suppose we apply this criterion to the comparison between the alternating-current and direct-current systems. By which of these systems can a given service be rendered most economically? In order to answer this question, we shall assume a certain typical interurban road, ascertain the first cost by both systems, and the cost of operating by both systems, and compare the results. Suppose the typical road which we will assume to be as follows:—

Length, 60 miles; schedule speed, 30 miles per hour. Cars running half an hour apart.

Number of stops, 30—that is, typical run, two miles long. Weight of direct-current car, complete, 35 tons; weight of alternating-current car, complete, 41.3 tons.

It may be noted here that the above difference in weight is not the minimum that can be obtained. A large part of the difference in weight comes, as previously stated, in the induction regulator, with which it is assumed the alternating-current car is equipped. Other methods of voltage control can be applied which would be considerably lighter, but the induction regulator is selected on account of the advantages previously mentioned. The alternating-current system is, therefore, working under a handicap which is greater than would be the case if some other method of control were assumed.

Fig. 1 shows the speed, time and K. W. hours curve of a direct-current car of 35 tons over the typical run of two miles.

Fig. 2 shows the same for an alternating-current typical run and in addition gives also the apparent kilowatt and power factor. It will be noted that the difference in power at the car is only 10 per cent. in favor of the direct-current equipment, in spite of the fact that the difference in weight is 18 per cent. in favor of the direct current, the weight of the alternating-current motor car being 41.3 tons.

The location of the power house is assumed in both cases to be on the line of the road, midway between the termini.

In each case, also, one of the sub-stations is located in the power house. In the alternating-current proposition the generators are wound for trolley voltage (3000 volts) and feed directly into the trolley wire. In each case, also, there are supposed to be four feeding points beside the power house, thus making the sub-stations 12 miles apart in both cases.

Further, in both cases the secondary system is a single network, thus gaining the advantage of two feeding points except beyond the end sub-stations. In neither system are secondary feeders figured on, the alternating current being simply a No. 0000 trolley wire throughout, and the direct current a 60-pound conductor rail. In the direct-current system the high-tension line is supposed to be along the right of way of the road and the high-tension poles are utilized for supporting the trolley wire with a bracket construction.

Recognition of the fact that the alternating-current car is the heavier and requires more energy, is made and larger motors than on the direct-current car are estimated on. In the direct-current proposition the generators, transmission line, etc., are sup-

posed to be three-phase, naturally making necessary smaller transformers than in the single-phase system.

The annexed parallel columns give complete comparisons of the power consumption, the losses in the various transmissions and transformations, the first cost of the apparatus used and an estimate of the operating expenses. The conditions are taken as nearly as possible like those in the typical road. Location will, of course, make differences in many of the items considered, but especial care has been used in estimating those items in which the two systems present a difference.

First Cost.—In the first cost of the two systems above compared, no allowance is made for the fact that the alternating-current system requires less energy at the power house, and therefore will economize to a considerable extent in both engines and boilers. On account of the greater apparent kilowatts for the alternating-current system, generators and transformers will be larger in capacity, but the engines and boilers need not be so great in capacity. So far as transformers are concerned, the alternating-current system has the advantage, because it allows the use of considerably larger units than the direct-current, with which three-phase transmission is necessary instead of single-phase, as is the case in alternating-current system. The alternating-current switchboards also have the advantage in that only two switches per panel are required instead of three.

To render a given service over a high-tension line, more copper is required for a single-phase line than for a three-phase line, and this makes the copper for the alternating-current system somewhat more expensive than for the direct-current system. The largest difference, however, in the high-tension line items comes from the fact that the poles for the high-tension line are spaced sufficiently close to allow the trolley brackets to be supported from the same poles. In the direct-current system, the spacing need be only sufficient for the requirements of the high-tension line alone.

So far as sub-station transformers are concerned, the alternating-current system has the advantage of single-phase over three-phase, in that larger units are used. By far the largest item of saving in sub-station equipment between the two systems is of course in the omission of rotary converters in the alternating-current system.

The greatest difference in first cost of the two systems is of course the great difference in the cost of the secondary net-work. A glance at the comparative values will show that this

DIRECT-CURRENT RAILWAY SYSTEM. ALTERNATING-CURRENT RAILWAY SYSTEM.

POWER REQUIREMENTS.

Direct-Current Railway System.

Average K.W. at car in typical 2-mile run (fig. 1)	67.2 K.W.
No. cars running at one time	8
No. sub-stations	5
Average No. cars per sub-station	1.6
Mean 2 amps. per car	185.3
Mean 2 amps. per sub-station = m	279.0
With sub-stations 12 miles apart, 80 lbs. track rail and 60 lb. 3rd rail resistance between adjacent sub-stations is	= r. 0.9 ohms
D.C. line loss per sub-station, $\frac{r\,m^2}{6} =$	16.1 K.W.
Average K.W. per sub-station at cars	= 67.2 x 1.6 = 107.5
Average K.W. per sub-station at sub-station	123.6 K.W.
Per cent loss in 3rd rail	15.5%
Per cent loss in step-down transformers	3.5%
Per cent loss in rotaries	10 %
Per cent loss in high-tension line	2.5%
Per cent loss in step-up transformers	3.5%
Total percentage loss from cars to P.H.	39.5%
Average K.W. consumed by 8 cars at the cars	537 K.W.
Average K.W. at power house for 8 cars	750 K.W.
Max. load per sub-station—worst condition 2 cars starting	560 K.W.
One 400 K.W. rotary will take care of this 40% overload.	
Average load on rotary	30%
Rotary sub-stations are of sufficient size so that one can be cut out temporarily.	
Max. load on power house, say	1200 K.W.
Can be taken care of with three 400-K.W. generators—one for spare.	

Alternating-Current Railway System.

Average real K.W. at car in typical 2-mile run (Fig. 2)	73.9 K.W.
No. cars running at one time	8
No. sub-stations	5
Average No. cars per sub-station	1.6
Mean 2 apparent K.W. per car	129.0
Mean 2 amps. per car (3,000 volts)	43.0
Mean 2 amps. per sub-station = m	68.8
With sub-stations 12 miles apart 80 lbs. track rail and No. 0000 trolley resistance between sub-stations, allowing for increased rail resistance	4.2 ohms
Trolley and rail loss per sub-station, $= \frac{r\,m^2}{6} =$	3.32 K.W.
Average real K.W. per sub-station at cars = 73.9 x 1.6 =	118.0
Average real K.W. per sub-station at sub-station	121.32 K.W.
Per cent loss in regulator and car transformer	5.0%
Per cent loss in trolley and rails	2.8%
Per cent loss in step-down transformers	3.5%
Per cent loss in high-tension line	2.5%
Per cent loss in step-up transformers	3.5%
Total percentage loss	18.4%
Average real K.W. consumed by 8 cars at the cars	591 K.W.
Average real K.W. at power house for 8 cars	700 K.W.
Average apparent K.W. at power house, about	825 K.W.
Max. load per sub-station—worst condition, 2 cars starting (say 275 apparent K.W. each)	550 K.W.
One 350-K.W. transformer will take care of this with 50% overload.	
Average load on sub-station, about	40%
These transformers are sufficiently large to take care of road if one is cut out.	
Max. load on power house in apparent K.W., say	1400 K.W.
Can be taken care of with three 450-K.W. Generators—one for spare.	

STEP-UP TRANSFORMERS.

Direct-Current	Alternating-Current
Seven 150-K.W. transformers—1 for spare.	Three 400-K.W. transformers—Load can be carried by 2 in case of emergency.

HIGH-TENSION LINE.

Direct-Current	Alternating-Current
One No. 6 B. & S. gauge line each way from power house 20,000-volt, 3-ph.	One No. 3 B. & S. gauge line each way from power house, 20,000-volt, 2-ph.
Max. loss, about 8.25%	Max. loss, about 8.2%
Aver. loss, about 2.50%	Aver. loss, about 2.7%

SUB-STATION EQUIPMENT.

Direct-Current	Alternating-Current
Five sub-stations in all—one in power house.	4 sub-stations—power house feeds directly into 300-volt trolley.
Each of four sub-stations to contain:	Each sub-station to contain:
Three 135-K.W. step-down transformers.	One 350-K.W. transformer.
One 400-K.W. rotary converter.	Switchboard.
Switchboard.	
Step-down transformers omitted in power house sub-station.	

LOW-TENSION DISTRIBUTING SYSTEM.

Direct-Current	Alternating-Current
Entire length of track equipped with 60-lb. conductor rail.	Entire length of track equipped with No. 0000 B. & S. gauge trolley.

CAR EQUIPMENTS.

Direct-Current	Alternating-Current
Each car equipped with two 150-H.P., D.C. railway motors and multiple-control apparatus complete.	Each car equipped with two 165-H.P., A.C. railway motors and multiple-control apparatus complete.

ESTIMATED FIRST COST OF ELECTRICAL EQUIPMENT.

POWER STATION:

Direct-Current		Alternating-Current	
Three 400-K.W. 25-cycle, 360-volt, 3-ph., A.C. gens., at $6,500 each	$19,500	Three 450-K.W., 25-cycle, 3000-volt, 1-ph., 2000-alt. gens., at $7,000 each	$21,000
Seven 150-K.W., 350 to 20,000-volt, self-cooling, oil-insulated trans., 25-cycle, at $1,225	8,575	Three 400-K.W., 17-cycle, 3000 to 20,000-volt, O.I.S.C. trans., at $2,500	7,500
Switchboard	4,500	Switchboard	3,800
	$32,575		$32,300

HIGH-TENSION LINE.

Direct-Current		Alternating-Current	
48 miles of 20,000-volt, 3-ph. transmission line—No. 6 B. & S. gauge conductors, at $900 per mile	$43,200	48 miles of 20,000-volt, 1-ph. transmission line—No. 3 B. & S. gauge conductors, at $1,200 per mile	$57,600
Lightning protection	2,500	Lightning protection	2,000
	$45,700		$59,600

SUB-STATIONS.

Direct-Current		Alternating-Current	
12 135-K.W., 20,000 and 360-volt, 25-cycle, O.I.S.C. transformers, at $1,175 each.	$14,100	4 350-K.W., 2000-alt., 2000 to 3000-volt, O.I.S.C. transformers, at $2,200 each	$8,800
5 400-K.W., 600-volt, 25-cycle rotary converters, at $5,200 each	26,000	5 switchboards, at $1,500 each	7,500
5 switchboards at $2,800 each	14,000	Auxiliary signaling lines for operating sub-station switches	7,500
	$54,100		$23,800

LOW-TENSION DISTRIBUTION SYSTEM.

Direct-Current		Alternating-Current	
63 miles of 60-lb. conducting rail, at $2,500 per mile, installed	$157,500	63 miles of No. 0000 trolley wire in place, at $900 per mile	$56,700
Bonding main track—63 miles, at $400 per mile	25,200	Bonding main track 63 miles, at $400 per mile	25,200
		15 miles of pole construction, not including H.P. lines, at $630 per mile	9,400
	$182,700		$91,300

DIRECT-CURRENT RAILWAY SYSTEM.		ALTERNATING-CURRENT RAILWAY SYSTEM.	
CAR EQUIPMENT.			
12 D.C. car equipments complete, consisting of 2 No. 50-C. motors, with multiple-control outfit, heaters and contact shoes, at $5,217 each..........	$62,604	12 A.C. car equipments complete, consisting of 2 165-H.P. motors, with multiple-control outfit, heaters and trolley, at $8,482 each....................	$101,774
Total first cost electrical equipment.	$377,179	Total first cost electrical equipment.	$308,774
ESTIMATE OF YEARLY OPERATING EXPENSES.			
5 men at power house—2 shifts, aver. wage $900 per year....................	$9,000	5 men at power house—2 shifts—aver. wage $900 per year each..............	$9,000
1 man at each of 4 sub-stations—2 shifts —at $900 per year each	7,200	Fuel, water, oil, etc., at ½c. per K.W.-hour	23,050
Fuel, water, oil, etc., at ½c. per K.W.-hour, 4,890,000 K.W. hp...............	24,450	Repairs and maintenance of power house (3% of cost)..................	969
Repairs and maintenance of power house (3% of cost per year)..........	971	Repairs and maintenance of H. T. lines (5% per year)	2,980
Repairs and maintenance of H.T. line (5% of cost per year)	2,285	Repairs and maintenance of trolley (4% per year)	3,652
Repairs and maintenance of 3rd rail (1% of cost per year)	1,822	Repairs and maintenance of car equipments (10%)	10,177
Repairs and maintenance of car equipments (12% of cost per year)..........	7,512		
Total yearly operating expenses	$55,404	Total yearly operating expenses.........	$51,256

difference in the case considered amounts to nearly $100,000, and is therefore nearly 30 per cent. of the total cost of the direct-current system.

In first cost the alternating-current car equipments are, of course, considerably higher than the direct-current equipments. But the writer would call attention to the fact that the costs of the alternating-current car equipment include an induction regulator. If some other style of regulator, such as, for instance, loops on the car transformers, had been figured upon, the cost of the alternating current car equipments might have been diminished by something like 6 per cent., that is, something over $6,000. The saving in weight by the same change and the consequent saving of power in the alternating-current system would amount to nearly 4 per cent. of that which has been figured upon. In the item of maintenance of the control apparatus, however, it is believed that the induction regulator has the advantage in that it is not necessary to break the current in going from step to step.

The alternating-current system throughout is figured on the basis of using a frequency of 2,000 alternations per minute. This frequency could be increased to, say, 3,000 alternations per minute at the expense of, first, a considerably decreased power factor and consequently increased apparent kilowatts; second, increased generator and transformer capacity; third, increased line and rail loss; and fourth, increased cost of motors. This difference might run the cost of the alternating-current car equipment 5 per cent. higher than figured on. It will be noted that the great saving comes in changing from direct current to alternating current, and that a change in frequency within moderate limits effects a change by no means comparable with that which is effected by going to alternating current.

Operating Expenses.—In the labor item it will be noted that the main saving comes from the circumstance that sub-station attendance is avoided by the use of the alternating-current system. In other respects the labor items will be the same.

The fuel item for the alternating-current system is somewhat smaller than for the direct-current system, as the actual energy at the power house is less in the former case than in the latter.

Besides labor and power, the main operating expense for any interurban railway system comes in the items of repairs and maintenance. It will be noted that this item of repairs and maintenance has been included in the above comparison by assuming that it is a certain percentage of the first cost in each case. There may be a difference of opinion as to the percentage that should be assumed in the various cases of this item of repairs and maintenance, but I have endeavored to make the comparison between the two systems as fair as possible. It is not intended to include any item of depreciation in these repairs and maintenance figures.

It will be noted that a marked difference is made between the maintenance of a third rail and trolley by allowing 1 per cent. in the one case and 4 per cent. in the other. The apparent discrepancy in allowing 5 per cent. for the maintenance and repairs on the high-tension line and only 4 per cent. for that of the trolley is explained by the fact that the 5 per cent. on the high-tension line include the repairs and maintenance and the supporting structure for the trolleys.

The matter of inspection of the alternating-current sub-stations is taken care of by allowing 6 per cent. in the case of the alternating-current sub-stations instead of 4 per cent. as in the direct-current sub-stations.

In the matter of repairs and maintenance of the car equipments, it will be noted that 12 per cent. are allowed in the direct-current system and only 10 per cent. in the alternating-current system. Even this difference in percentage allows $10,000 per year for the maintenance of the alternating-current equipments in the place of $7,500 for the direct-current, or 25 per cent. more for the alternating current than for the direct current. The alternating-current motors being lower in voltage, and being protected against direct lightning discharges by the intervention of a transformer, ought to have at least a no higher maintenance bill than the direct-current motors. The number of motors in each case is the same. The alternating-current system, however, will require a certain amount of attention for the transformers and regulators. This item, though necessarily not based on experience, is estimated to represent the comparative conditions as closely as is possible at this time.

At the request of the editor of The Electrical Age some supplementary remarks are here added. In the first place, the estimates made in the above-mentioned paper between alternating and direct current for a given hypothetical case are believed to be very conservative so far as the apparatus for the alternating-current estimate is concerned. The conservative tone in this estimate was adopted advisedly, since the writer believes that if any changes in the comparative estimate were to be made in the future, they should make a still better showing for the alternating-current system, rather than that the future changes should show a tendency in the opposite direction.

The apparatus which was estimated upon was that which had already been built and tested at the time the above paper was written, but already alternating-current equipments have been laid out which are cheaper and lighter than the one estimated upon here. The difference in weight between the alternating-current and direct-current cars complete is taken in the paper as about 18 per cent. of the direct-current car. This difference is expected to be cut down so that the difference will be only about 5 or 10 per cent. in favor of the direct-current car.

The difference in cost between the direct-current and alternating-current electrical equipments as given in the last item of first cost shows that the alternating-current equipment is about 65 per cent. more expensive than the direct-current equipment. With continued improvements it is certain that this difference will be

largely cut down. In the paper, therefore, the alternating-current equipment was laboring under the disadvantage of high cost which invariably occurs in the early stages of the development of a given line of apparatus.

An element of the alternating-current estimate to which considerable exception has been taken is the use of so high a trolley voltage, namely, 3,000 volts. It has been contended that this voltage is unsafe for use upon cars of the description estimated upon. This high voltage, however, goes only as far as the car transformer. The major part of the apparatus on the car is operated at voltages which are very much lower than the standard in use on the direct-current systems of to-day. The wires from the trolley to the transformers in the equipments which have been projected may be strung throughout in metal conduits which are thoroughly grounded. This construction makes it practically impossible for the high voltage to be communicated to passengers. The apparatus from which the current is most liable to escape is the motors and control devices. This apparatus is all operated, as stated above, at a voltage much lower than in direct-current practice, and for this reason there is foundation for the position that on the score of safety the alternating-current equipment is actually safer than a corresponding direct-current outfit.

High trolley voltage, however, is not an essential element of the alternating-current system. Trolley voltages corresponding to standard direct-current practice can be used, and at the same time the advantages of the alternating-current system can be retained. To obtain these advantages, it is necessary only to space the alternating-current sub-stations closer together. For instance, doubling the number of sub-stations, that is, making their distance apart one-half, makes the loss in the secondary one-half, provided the secondary distributing system is not reduced in size.

It is evident that this subdivision of sub-stations can be carried to any limit desired and that, therefore, the losses in the secondary distributing system can be carried down to any limit desired. The disadvantage of increasing the number of alternating-current sub-stations is the additional cost per kilowatt for the smaller transformers, the additional cost for the smaller sub-station buildings, switchboards, etc., and the lower efficiency which accompanies smaller sizes of transformers. Another limit also occurs in that the transformer sub-station cannot be reduced below a point where a single sub-station cannot carry the maximum current required by a train in starting. When a train starts near a sub-station, practically all the energy required by that train comes from that sub-station. This objection is to a large extent offset by the well-known ability of transformers to carry excessive momentary overloads.

In the estimates contained in the paper above referred to, the subdivision of transformer sub-stations can be easily carried to a point where a voltage equivalent to standard direct-current practice can be used in the same secondary distributing system without increasing the loss and without increasing the cost of the sub-stations to a point where this increased cost will make a material difference in the saving. The fact that alternating-current sub-stations require no manual attendance makes this subdivision possible. In the direct-current system, subdivision of sub-stations is accompanied by a marked increase in operating expenses on account of the additional attendance required. It is in this matter of sub-station attendance that a marked difference occurs between the two systems.

Another point of advantage of the alternating-current system over the direct-current rotary converter system which was not touched upon in the preceding paper is the time required to get the system started after a general or partial shut-down has occurred. In the rotary converter system, after a shut-down, it is necessary to start and synchronize the rotary converters in the sub-stations before power can be supplied to the cars. This is a matter of considerable time. If the cars on an extensive system are able to start within half an hour after the generators at the power house have started, most railway superintendents would feel that they had reason to congratulate themselves. In the alternating-current system, on the other hand, the cars can be started immediately upon closing the switches at the central station. This elimination of the elements of delay in starting after a general or partial shut-down is a very important one.

Another advantage possessed by the alternating-current system over the direct-current is the overload capacity of the sub-stations. This was mentioned above, but the writer considers it well to emphasize this point. In the direct-current sub-station there are two elements which limit the output; first, the element of heating, and, second, the element of commutation. The element of heating limits the average load which can be carried by the sub-station to an amount which will not raise the temperature above the danger point. The element of commutation limits the maximum which can be taken from a given sub-station. Invariably rotary converter sub-stations are proportioned rather on a basis of the maximum that can be commutated than for their heat capacity.

In the alternating-current sub-stations, on the other hand, the element of commutation is cut out and the only limit to the power output is the heating capacity. The capacity of sub-stations, therefore, in the alternating-current system can be much more nearly adjusted to the average power output than is the case in the direct-current system. It is evident, therefore, that the aggregate capacity of sub-stations for an alternating current proposition may be made less as a rule than for an equivalent direct-current proposition.

This element of overloads which can be carried by sub-stations also is of the utmost importance on occasions when the traffic of a given road becomes congested for any reason. An accident to a train or to the track is almost certain to cause such delays as will pile up the cars to be started and operated at that particular point when the stoppage is cleared up. Such a condition throws an abnormal load upon the sub-stations located at, and near, the point of accident, and in taking care of such a condition it is evident that the alternating-current system has considerable advantage.

By adopting a rheostatic control for alternating-current equipments, the same system of control can be used whether the car be running from an alternating current circuit or from a direct-current circuit. It is true that such a system of control does not give the maximum available economy when running from the alternating circuits, but it does give an economy which is comparable directly with that obtained in the present direct-current systems.

It would be well for those who are operating electrical railways and looking out for their future needs, to investigate the possibility of making their additions, when additions are made, with a type of motor which, although it is purchased for direct-current circuits, can eventually be used on an alternating current circuit, thus keeping in mind the time in the not distant future when a general change from the present direct-current to the future alternating-current systems may be expected.

Over 300,000,000 passengers were carried by the street railroads of Berlin, Germany, last year.

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Leading Articles

Uncalled-for Applications of Wireless Telegraphy

It is obvious that wireless telegraphy is applicable to almost any of the commercial uses to which wire telegraphy has been put, within certain limits, as, for instance, the distance to which signals may be successfully transmitted by the wireless system. This being true, it is very clearly evident that it should be quite feasible to make use of the latter system in exactly the same way that wire telegraphy is used. Hence, if Mr. Paul Jones runs short of ready cash while on a transatlantic trip and knows that Père Jones is on a sister ship, it is not a miracle to send a message by wireless, if both vessels are equipped with wireless outfits, in order to obtain an order for more of the needful from Père Jones to Jones Fils. Yet the prominence given in the daily press to so simple a transaction would imply that there was something of the supernatural about it. It is also quite apparent that if wireless telegraphy is practically operative at all, it should be feasible to apply it as a means of communicating to and from moving trains. Hence we hear of various inventors who are assiduously applying themselves to accomplish this result, seemingly without asking whether, if their efforts should be successful, there would be any demand for such a system of inter-communication. It is not novel to accomplish such a result. It was done long ago by Phelps, Edison and others by induction telegraph methods in a very simple and successful manner, but there was no demand for it; and it is, therefore, not likely that a system not nearly so simple, economical, or, it may be assumed, reliable, will create such a demand.

Another somewhat unnecessary proposed use of wireless telegraphy has recently been proposed and tested, namely, for automatic fire alarm telegraph purposes. For this work nothing could well be more simple, reliable and practical than the ordinary wire circuit connecting the building to be protected with firemen's headquarters. Such an alarm system, to be of any practical utility, must give automatic evidence of some kind when defects of any sort arise; or it must be feasible to test the circuits and apparatus at regular intervals. All this is readily done from headquarters by the existing wire telegraph systems, with little or no complications at the protected building. With wireless telegraph apparatus, however, a complete transmitting and receiving system would be necessary at each protected building to effect the results just mentioned, the cost of which would, doubtless, be many times more than the cost of a connecting wire. Besides, who is to keep the coherer, induction coil, battery, and other accessories in adjustment night and day in the various stations? The moral of which remarks is, why waste time, energy and money in demonstrating that certain things can be done by wireless telegraphy when they can be, and are, done much more satisfactorily by other means?

The Third-Rail Problem

The dangers of the third-rail current supply system on electrically operated elevated railways, and others, with special reference to what has been done on both the elevated and the new tunnel lines in the city of New York, has been so prominently presented of late, largely from one point of view, that it is proper to look at the subject from a few other points as well.

One of the principal contentions that have been made is that the third-rail system is inherently faulty and objectionable, and that an overhead current supply should have been installed at the outset; but in taking this stand sight has apparently been lost of the fact that traffic and other conditions on surface lines and in small towns or along country highways differ in every way from those ruling on the elevated and tunnel routes of New York. In one case we have isolated groups of motor units, on cars running at intervals, while in the other we have concentrated groups, the usual motor equipment for an elevated or tunnel railway train averaging about 1,000 horse-power. With present methods of operation no ordinary size of trolley wire would be

sufficient to carry current for this, and the kind of conductor that would have to be adopted would require something far more substantial in the way of overhead support than the now customary trolley construction. For elevated railways it would mean more substantial poles, or more closely spaced poles, and light cross girders instead of wires for conductor suspension, forming what the public, and especially the fire department of a city like New York, would consider an intolerable overhead addition to the railway structure itself.

The fire department might reasonably be expected to take the position that such additional overhead erections would seriously hamper it in fighting fires along the line of the railway, while adjacent property owners would probably also object. At present, elevated railway structures are frequently used as points of vantage by the firemen in their work, and this possibility would be largely, if not altogether, eliminated by the kind of substantial trolley superstructure that proper train service would require.

As to an overhead conductor in the New York rapid transit subway, that is barred out at once by the fact that the space between the roof of the tunnel and the tops of the cars amounts to only four inches. No overhead trolley mechanism could be put in that space. Sinking the conductor between the rails or at the side of the rails after the manner of the slotted conduit construction of the electric surface lines would be impossible, also, on both the elevated lines and in the tunnel as now built, unless the approved present method of supporting rails upon cross ties in heavy railway construction of this character were abandoned.

Conduit systems of various kinds, with no current-charged conductor exposed, button systems as they have been called, and induction systems with alternating current motors, all have been proposed from almost the earliest day of electric railway construction, but they have rarely gone much beyond the purely fanciful stage, and none of those which have actually been tried have been able to withstand the test of practice.

There remains thus, with the present state of the art, the much-abused third rail as the only method of current supply which rests upon experience as a reliable means of conveying the necessarily heavy currents to elevated and subway trains, though it must be admitted that some method of guarding this rail more efficiently than is done now should be adopted; and right here it should be said that the Interborough Rapid Transit Company of New York, which has been so freely criticised for its apparent neglect of public safety considerations in this respect, is heartily in favor of the right kind of third-rail guard, and is at present engaged in a careful investigation of the merits of the multitude of such guards which have been proposed. The right kind of guard will make the rail fool-proof, and it is that quality which is needed for it more than anything else.

New York's Proposed West Street Overhead Trolley Line

THAT a city of the first magnitude, like New York, should have been one of the latest to avail itself of the advantages of electric traction on its street railways, was, several years ago, a matter of amused comment with many. But from this very slowness of action was finally evolved an electric system superior, as a whole, to anything anywhere else,—a perfected conduit system, with not a wire overhead,—and the final verdict was, unqualifiedly, that the city's stubborn opposition to the overhead trolley had been wisely and well maintained.

Recently, however, with the overhead wire battle supposedly thoroughly fought out and the matter definitely disposed of for all time, came the proposition to equip one of the still existing horse-car line relics along the Hudson River front with the overhead trolley system. Horse traction was sadly behind the times, the sub-surface conduit system used elsewhere in the city was inadmissible on account of the trouble which was to be anticipated from the very frequent flooding of the river front street at high tides, and the overhead trolley was, therefore, the only practicable thing to install. This, in brief, was the contention of the operating company.

Happily, however, permission to put in the overhead trolley has not yet been granted by the city, and it is to be hoped that the authorities will firmly support their anti-overhead decision of earlier years. In taking this stand, it is presumed that what the street railway company have in mind is the single-trolley system; indeed, there has been nothing to indicate that anything else had been thought of. With this system in operation, both city and railway company would at once have to contend with the electrolysis problem, and the serious aspect of this cannot be too strongly urged for consideration. Every city in which the single-trolley is in service has had to grapple with it, and where, in such cities, the trouble has not yet been serious, it certainly will be unless the proper remedies are applied in time.

In the case of the proposed Hudson River front trolley line, it is easy to foretell what would happen. West Street, along which it is to be erected, runs along the West Side, practically north and south, in the direction of the city's length. The electric current for the line would presumably be supplied either from the company's power house on the extreme opposite side of the city, on the East River front, or from a second one at a point also many miles north-east from the lower part of the city, or from both. The stray return currents from the trolley line would thus flow from south-west to north-east across the city, through all available underground metals, water and gas mains, the metallic construction of subways, and all sorts of buried lead-covered electric cables in a large section of the lower part of Manhattan, and would introduce a situation which would have to be seriously reckoned with before long. The responsibility of the railway company for future damage to underground metals, if allowed to install the single-trolley, would be all the more pronounced, as the effect of that system in causing electrolysis is now so well known, and with the likelihood, therefore, in view of being saddled with heavy reimbursements for pipe and other metal destruction, the company might well be expected to hesitate before installing this particular overhead system.

At all events, the position of the power house and every detail concerning the establishing of such a system should be clearly explained by the railway company; the piping maps of the city should be consulted to determine upon what gas and water mains and other metals the flow of current would be likely to pass; where they may be affected, and how the return circuit is to be constructed. These and other questions should be carefully considered by the authorities before giving consent to the installation of the single trolley on West Street. It has been shown in several instances by expert investigation that some current will always return by underground mains of various kinds, no matter how excellent the construction of the regular railway return circuit, and as the conductors of the circuit in this case would always be exposed to wet soil, deterioration would constantly go on, and the flow of current to other metals would increase in proportion, as the track circuit lost in conducting capacity.

It may not be amiss before leaving

the subject here to direct attention to the article entitled "Electrolytic Decomposition of Metals Underground," by Mr. A. A. Knudson, printed elsewhere in this issue. Mr. Knudson speaks from many years of experience which give a distinct practical value to his observations.

The Underwriters' Electrical Rules

THE Underwriters' Electrical Rules, be it said without disparagement, are an anomaly, both in the conduct of insurance matters and also from the peculiar position which they occupy, not merely in relation to the insurers and the insured, but in their relations to manufacturers and users of electric lighting and power apparatus, the government of municipalities and even States, and also the general conduct of all forms of electrical application which are made for the service of the public.

Underwriting pure and simple is a distribution of the losses of the few upon the many, by a system of selective taxation, from which a quotum is abstracted to serve as the stipend for the cost of the transaction. In former years it was the practice to insure property at a rate based on the estimated hazard to take the chances, and to protect the assets of the company by the rate charged for assuming the risk of fire. In later years, however, underwriting, like other occupations, has been modified by the scientific methods which have reached every occupation, and instead of making merely a discrimination, based upon the estimated hazard, such concessions are made in the rates for the introduction of special protective apparatus, the adoption of more stable methods of construction, the introduction of preventive measures in automatic fire alarms, watchmen, and systematic care of the property, especially as regards removal of waste material, and both insurers and insured have profited by the modification.

With the introduction of electric lighting it was found that its fire hazard was not like some other dangers, necessarily an inherent part of the system, but it could be modified in many respects by specifications governing the constructive methods of installation and conduct of its affairs.

From a very small beginning rules were first prepared governing the conditions as they were known at that day, and they have been amplified to keep pace with the progress in the construction and application of electricity to light and power, confining their provisions to matters which have some bearing on the fire hazard as determined by experience. In their present form, as matters exist to-day, they are the outcome of a meeting known as the National Conference on Standard Electrical Rules, which was held at New York in March, 1896, and at which several days were devoted to the consideration of the numerous electrical rules issued by various bodies, both in America and Europe, and all suggestions for changes, to which were added many recommendations received by correspondence in reply to circular letters sent out by that body, were referred to a Committee on Code, which codified the whole matter on a systematic basis.

The rules were accepted by the insurance interests, and by the National Board of Fire Underwriters, and have been accepted as the guide and authority upon questions relating to the fire hazard of electricity.

The conference consisted of representatives of the underwriters, manufacturers of operating electrical interests, and delegates from numerous technical and scientific associations. The Underwriters' National Electric Association, consisting of electricians in the services of the underwriters, was reorganized as the result of one of the congresses of the Chicago Exposition of 1893, and the Electrical Committee of that organization, consisting of eleven members, meet once a year in public convention, at which other members of the Association, and also underwriters interested, meet to consider the various changes made necessary by the year's progress.

The anomalous position of the rules arises from the fact that the Electrical Committee, which meets and amends them, as may be required, and then recommends them issued in pamphlet form from year to year, is a purely voluntary organization, without standing as a corporation. The rules are issued as representing the minimum of conditions compatible with safety, although those engaged in the manufacture, installation and operation of electric lighting and power plants use precautions not included in these rules, and yet the committee has no power of enforcement, nor do the rules prescribe any penalties for their violation. As a matter of fact, however, the rules meet with the utmost consideration by those concerned in the manufacture and installation of electrical apparatus, and generally form a part in contracts for such work.

Owners of buildings demand that the installation of electrical apparatus shall be made in exact conformity to the provisions of these rules, and in these several respects the rules are probably more specifically obeyed than a great majority of laws backed by governmental power. The reason for this is, primarily, that they receive the confidence of all parties interested, it being believed that they work for the good of all connected with electricity, and the rate-making organizations connected with the underwriters give such weight to the conditions set forth by these rules that their continued and deliberate violation would, indeed, be an expensive matter for owners of such insured property. The rules are embodied in many city ordinances, and have an influence in State legislation bearing on the subject. They form the guide to insurance inspectors and to many municipal inspectors.

The point of criticism which has been offered is the lack of a deciding body to pass upon disputed questions in the interpretation of the rules, which questions arise as naturally as in other matters of contract or of law. It may be that in course of time something will be done to give a closer jurisdiction over the methods of electric inspectors in the service of the underwriters for the purpose of obtaining a uniformity of methods in applying the rules, as it is frequently claimed that there are wide differences in various districts. As the Electrical Committee is now constituted, a board of appeal was provided for a year ago, at the request of the National Contractors' Association, for the decision of disputed points of construction in which members of that organization have a business interest. But, as a matter of fact, since the provision of this board of appeal, all of the disputed points have been settled by the National Contractors' Association without an appeal being taken by either party, and it is stated that the existence of this provision for an appeal has made settlements of disputes feasible between the original parties.

The question naturally arises, to what extent do these rules carry out their purpose of establishing conditions of immunity? It is difficult to estimate the value of prevented losses; but it is true that the earlier electric lighting installations were accompanied by a relatively large number of fires, while now, though fires still occur, they are, in the main, due to a non-compliance with the rules or to depreciation which is beginning to show itself in many of the older installations.

The National Board of Fire Underwriters maintain an extensive laboratory at Chicago, where there are facilities of apparatus and technical assistants to test various forms of electrical devices and supplies which may be submitted for approval; and in the

course of these investigations new points are frequently developed, which accrue to the advantage of inventors and manufacturers.

The regulations apply to the vast amount of property included in the electric plants all over the country, engaged in transmitting enormous quantities of electric energy, in which mishaps may divert this potentiality from its good services in illumination or the transmission of power, to become an agency of destruction. To administer these regulations justly and conservatively is a grave responsibility, and it is, indeed, fortunate that they emanated from a technical source. With delayed action in formulating them, events might have occurred which might have imposed upon the electrical interests the hazards of unwarranted legislation.

The Insulation of Underground High-Tension Cables

THE question of the proper insulating material for underground cables for high tension circuits appears to be settling itself in favor of paper saturated with insulating oils. At one time rubber compounds were regarded with much favor for this work, chiefly because it was believed that cables thus insulated possessed two chances of life, as against one for paper insulation; which remark, translated, means that, since both types of cable are lead covered over the insulating material, if the lead cover is punctured or corrodes, moisture enters, and, in the case of paper insulation, a defect promptly ensues, while such injury to the lead casing does not necessarily mean immediate collapse in the case of the rubber-insulated cable.

Notwithstanding this advantage in favor of the rubber type of cable, however, it has hardly held its own in this country of recent years against paper insulation for high-tension service. In fact, in a number of instances a considerable quantity of rubber cables employed on high-tension circuits have, for reasons satisfactory to the user, been actually displaced by paper cables, the displaced cables being utilized in other ways where the service was not so exacting. The price of rubber-covered cable is, size for size, usually somewhat higher than that of paper-insulated cable, but in point of fact the question of relative cost of the cables does not seriously enter when the important factor of reliability of operation of the traction or lighting systems of large cities is at stake.

One feature of the operation of high-tension, heavy-current circuits in which the advantage rests entirely with paper cables is the apparently unavoidable, and more or less frequent, loading of the circuits with an amount of current largely in excess of the economical current-carrying capacity of the conductor. The undue heating of the conductor that follows such overloads is calculated to be more or less injurious to rubber compounds, whereas its effect is nil upon paper insulation.

The highest voltage employed thus far in underground cables in this country is 25,000 volts. This will soon be exceeded by an installation of several miles of paper cable, on which the pressure will be 30,000 volts. The thickness of insulating wall of the latter cable will be about half an inch. From the experience gained by the manufacturers in recent years, it is understood that they are ready to supply cables guaranteed to withstand 40,000 to 50,000 volts.

The three-phase, or two-phase, three-wire, system is now generally used for high-tension work, and the three conductors are laid up, or bunched, in one cable, with an insulating jacket over all, known as the "split" insulation plan. In this case, if half an inch of insulating wall is desired, the insulation over each conductor will be one-quarter inch, and the jacket will be one-quarter inch thick.

Concentric cables are not employed for high-tension work in this country, their mechanical disadvantages being considered as outweighing any electrical advantages they may possess.

It has been claimed for many years that the efficiency of paper cables depends very largely on the quality of paper used; namely, high-grade manila, and litigation for infringement of patents covering in certain ways the use of this material as an insulator has been going on for a decade, with the end not yet in sight, albeit the methods of the patents have been public property for some time. The object of the present litigation is to afford a basis for an accounting, and it is understood that several million dollars are involved.

In this relation, it may be of interest to note that much of the manila paper now on the British market is said to be mostly wood pulp and straw. The cause of this is attributed to a scarcity of manila fiber, as well as to the strictness of the specifications regarding the quality of paper, which, among other things, provide that the paper must be altogether free from knots and pin-holes, a requirement that cannot well be met in pure manila paper if the strength of the web of the fiber is to be maintained.

It is somewhat difficult, however, to understand wherein such pin-holes can detrimentally affect the general results in cables employing oil insulation, with strips of paper laid spirally over the conductor, and with lead over all. Possibly the specifications covering those points may be a tradition brought down from the gutta-percha specifications, in which pin-holes were guarded against by double lapping the material. There was good reason for this provision, however, in the case of gutta-percha insulation, which was usually employed for submarine cables, and without lead covering to exclude the water from the insulation.

In the United States the specifications for high-tension paper cables do not ordinarily specify the type of paper to be employed, but only the number of wrappings, thickness of insulating wall, breakdown test, and insulation resistance. With these features properly safeguarded, the quality of the paper is not considered of vital importance by the purchaser. The manufacturer, however, having his reputation to maintain, together with a guaranty of four or five years to protect, will see that the paper is the best obtainable for the purpose.

Opinions as to the utility of other than manila paper for such purposes are diverse among manufacturers, some standing out strongly for pure manila fiber, while others claim that, when strength, uniformity of texture, freedom from grits, metallic particles, pin-holes, and cost of the raw material are to be considered, a good quality of wood paper, made from clean sulphite pulp will, on the whole, give satisfactory results.

Put to the fresh college graduate the problem of the amount of distance to be left between the conductors of a high-tension transmission line, and his answer, Mr. Paul M. Lincoln, of the Westinghouse Company, recently remarked, most likely will involve the jumping distance of the voltage to be used, the length of span, the sag, and perhaps a liberal factor of safety. It is experience only that will show that his premises are wrong, and that the equation to determine the spacing of high-tension wires depends very little on the voltages to be carried and almost entirely on such things as the average length and ohmic resistance of cats, the spread of wings of owls, and cranes, and eagles, and the average length of scrap baling wire, together with the strength of the average small boy's throwing arm.

The Electric Locomotive in the Freight Service of the Trunk Line Railroad

A Proposed Use of Induction Motors and High Voltage

By CARY T. HUTCHINSON, Ph. D.

THE use of electric locomotives for heavy freight service on a trunk line railroad would, under ordinary circumstances, scarcely meet with respectful consideration from steam railroad engineers. In a special case, however, this proposal was not only considered carefully, but appeared to be, on the whole, an economical solution of a serious difficulty. The case seems to be of sufficient interest to warrant a brief description.

The problem to be considered was to provide for an increase of 50 per cent. in the freight-carrying capacity of a mountain division. The division in question was approximately 80 miles long. At the eastern end there was a heavy, ascending grade nearly 20 miles long, having an average grade of 2.2 per cent., with a maximum of 2.5 per cent.; at the western end there was, similarly, a descending grade 14 miles long, with about the same average and the same ruling grades. The intermediate stretch was approximately level, but had short grades as high as one per cent. In addition to the heavy grades, the curvature was excessively great.

Some method of increasing the capacity of this section by at least 50 per cent. was imperative. The cost of additional tracks would have been very large, owing to the necessity for long and expensive tunnels and heavy cuts. It was practically impossible to increase the average train load on the controlling grades with the locomotives in use, and the reduction of these grades to any material extent was out of the question, on account of heavy cost. Heavier locomotives could not be used on account of the curvature, which limited the rigid wheel base to about 10 feet, and more than three locomotives to a train, then sometimes used, seemed impracticable, and was not economical; hence a consideration of the use of electric locomotives suggested itself, by reason of the possibility of building locomotives of practically any weight with a short, rigid wheel-base. A locomotive of any weight could be made up by joining together separate truck-units, and in this manner the possible train load could be greatly increased and the train mileage correspondingly reduced.

The matter was investigated fully by Dr. Louis Duncan and myself. Estimates were prepared for the cost of operation by electric service, and were compared with the actual operating cost under conditions of operation then ruling. There were certain incidental advantages that made the electric service particularly favorable, one being that a large power plant could be placed in the immediate vicinity of mines furnishing the best grade of coal, which could be dumped directly from the cars into coal bunkers. The coal mines were owned by the railroad company, and the cost taken for coal—75 cents per ton—is the figure at which the engineers of the company estimated that coal could be delivered to the power house, making allowance for the short haul required. Water for condensation could be obtained from streams in the neighborhood, and could be brought to the power house without pumping; ashes could be washed from the power house by the discharge water into a ravine below. All these elements tended to make the cost of power low. There was the further possibility of the development of several water powers that would supplement the main steam plant. The investigation, however, did not go far enough to prove the economy of this; hence in the figures given below no account is taken of the possible operation of a water-power plant.

The length of this section of the road, as stated, was approximately 80 miles. The proposed location of the power house, as determined by the coal mines, was about 30 miles from one end and 50 miles from the other—an advantageous position, since the center of load was near this point, due to the fact that the eastbound tonnage was twice the westbound. This stretch made an operating division, and a certain amount of leeway was possible in train despatching, thus limiting the number of trains on the up-grade. This fact tended to improve the load conditions at the power house, and hence to cheapen the cost of energy.

One of the first facts brought out by the investigation was that the cost of doing this work by a direct-current, 500 to 700-volt system would be absolutely prohibitive, on account of the very large expenditure required for low-pressure distribution cables; hence resort was had to induction motors. The use of induction motors for this service offered one advantage of great importance — the motors themselves would act on the down-grades to hold back the train; that is, as electric brakes. This was valuable, as one of the chief difficulties in operating this section was to hold the trains on down-grades; the wear of car wheels and brake shoes was excessive. As the induction motors are used as brakes, it is as necessary to use such a locomotive as a helper on the down-grade as on the up-grade; hence the "idle" helper mileage is done away with. In addition, this brought about a considerable saving in energy; that, however, was not considered as important as the electric braking.

The service under consideration was the transportation of 50,000 tons of freight per day over this division, of which 34,000 tons were eastbound and 17,000 tons westbound. Under steam operation 52 trains per day were required to handle 32,000 tons, these trains making a total daily run of 4,100 miles. With electric service, using locomotives, it was possible to arrange the service so that a mileage of 2,100 was sufficient for the entire 51,000 tons. For a part of the run two electric locmotives were to be

used, and for part only one. The train load eastbound was increased to 1,700 tons on the up-grades, and 2,700 tons on the level stretches; westbound, the load from end to end was 1,700 tons. Under the conditions then existing it was impossible to haul more than 900 tons over the division, and to do this required a tender, which, when loaded, weighed 120 tons, making a dead weight of tender alone equal to nearly 12 per cent. of the total train weight. All this was saved by electric service.

It was proposed to use electric locomotives equipped with induction motors operating at 3,000 volts, the locomotives to weigh 150 tons, and to exert a continuous draw-bar pull of 60,000 pounds at 20 miles per hour. They were to have six pairs of drivers and six motors, one on each axle. The maximum speed was to be 20 miles per hour, but they were to be connected to operate also at 10 miles per hour at the same draw-bar pull. There was to be a single power plant, containing large three-phase units, operating at 20,000 to 30,000 volts. Energy was to be delivered to underground cables for the entire system. There were to be several transformer stations, changing the pressure from, say, 30,000 to 3,000 volts, at which pressure distributing cables, also underground, were to deliver the energy to the conductor rails, operated on a sectional system, so that the rails were alive only when a train was on the section. There were to be no overhead wires at any point.

The total estimated cost of this equipment, including a power-house of 30,000 kilowatts capacity, underground cable system, insulators, conductor rails, transformers, and 60 locomotives was from $7,000,000 to $8,000,000, depending upon the details of the plan adopted.

The cost of operation of the power house was put at 0.3 cent per kilowatt-hour. In considering this low figure, it must be remembered that coal cost in the bunkers only 75 cents per ton, and that the coal item in this total amounted to only 0.1 cent, leaving 0.2 cent for labor, repairs, and sundry items. There are a number of power stations in operation in which the total for all items, except fuel, is as low as 0.2 cent.

The cost of maintenance and inspection of the transmission and distribution system was estimated to be $150,000 per year. With these figures, the total cost per day for the different outputs of the power station was as follows:—

Daily Output in KW-hours	Cost per Day
100,000	$713
150,000	865
200,000	1015
250,000	1165

To move a tonnage of 150,000 per day required 150,000 kilowatt hours, making a daily cost of $865. The comparative cost of steam and electric service per train-mile on these assumptions was:—

		Steam	Electric
1	Engine Repairs	9.9 cts.	4.0 cts.
2	Wages, Firemen and Engineers	12.1	10.0
3	Wages, Train Crew	9.0	7.0
4	Fuel	13.3	----
5	Other Expenses	5.2	47.5
	Total per Train-mile	49.5 cts.	68.5 cts.

A comparison of the operation of the two services gave the following results:—

	Steam	Electric
Tonnage per day	51,000	51,000
Mileage per day	6 500	2,100
Cost per Train-mile	$0.495	$0.685
ost per day	$3,220	$1,440
Saving by Electricity per day		$1,780
Saving by Electricity per year		$650,000

In these tables the cost of the steam service was based upon the cost of operation of the road under existing conditions; the cost for the electric service was arrived at by consultation with the engineers of the road, and after as thorough a consideration of the problem as was possible. For the electric service, the first item, "engine repairs," was based on the experience of the Baltimore & Ohio Railroad in the operation of the electric locomotives that it had used for several years. The second item, "wages of firemen and engineers," was taken at a slightly less figure than the corresponding item for steam service. This was on the assumption that two engineers would be required on the electric locomotive on a train, but only one on the helper, or switching locomotive, and that the proportion of "idle" helper mileage was cut down greatly. It is probable that this item would have been reduced still further by lesser wages that could be paid to the electric engine drivers. The wages of the train crew were reduced, on the assumption that one member of each train crew could be dispensed with. The braking would be done principally by the motors, and the train crew would have comparatively little to do. The last item in the cost of electric service is the total cost of operation and maintenance of the electric system itself, based on an output of 150,000 kilowatt hours per day, and assuming a loss of 15 per cent. from power house to motors. The total cost per train mile is 68.5 cents for electric service, as against 49.5 cents for steam—a considerable increase; but the reduced mileage required makes an annual saving of $650,000. This is, say, 8.65 per cent. to cover interest and depreciation.

There are several other ways in which electric operation would show a saving over steam operation, but it is hard to estimate their money value. There should be a reduction in the cost of maintenance of permanent way, of structures, and of cars. Because of the very heavy grades, the rails on this division wear out very rapidly. With the reduced wheel base proposed for electric locomotives, there should be a decided improvement at this point. Similarly, with electric locomotives there would be no reciprocating motion, and, what is more important probably, no "nosing," or side pressure, on the rails, tending to spread them. Further, the entire cost of maintenance of water tanks and coal station would be eliminated, and the train mileage necessary to supply coal to the different coaling stations — a considerable item — would be saved. There would also be a saving in the maintenance of car equipment, due to the use of the motors themselves as brakes. The number of flat and broken wheels and the wear of brake shoes is very great on this division.

Electric service would show increased economies with each increase in tonnage hauled. The equipment as estimated here, except for the increase in the number of locomotives required, would be sufficient for a large addition to the tonnage; in fact, for a tonnage of 75,000 per day, the increased investment would be only about $1,500,000, and the train-mile cost would be reduced to 58 cents.

These figures of an actual case indicate that under some conditions even the hauling of heavy freight trains by electricity may be well worth serious consideration.

An Electrical Apprenticeship School

THE General Electric Company has established a school in connection with its apprenticeship course at its Lynn (Mass.) works. Graduation from the grammar school is required as a qualification in entering upon apprenticeship work, and the apprentice school supplements in a practical manner the ordinary grammar school work. The teachers in the school are practical men, such as engineers, draftsmen and foremen, and are consequently in daily touch with the practical work of the factory and factory requirements. The curriculum of the school lays special stress upon the practical application of arithmetic, the study of practical physics and manufacturing processes in general. The object of the school is to get young men capable of assuming broad responsibilities and of becoming foremen, superintendents, etc.

Edison Central Station Lighting and Power Service on Manhattan Island

From 1882 to 1903

By J. W. LIEB, Jr., Associate General Manager of the New York Edison Company

SEVERAL years ago, in an address before the New York Electrical Society, the writer gave some reminiscences in connection with the starting up of the old Pearl Street Edison station in the city of New York, and a brief outline of the electric lighting industry up to the time when that station was put into operation. It may be of interest here to review the substance of that address, and then institute a comparison with the Waterside station of The New York Edison Company, which at the time of its inception marked an important step forward in the progress of the art of electric lighting from central stations.

The retrospect is in this case particularly instructive, for, aside from the arrangement of the engines which in the old Pearl Street station were located on a steel structure above the boilers, that station was a prototype of many installed in later years, and in one respect at least it was superior to any installed in the following decade, namely, in the use of direct-connected generators.

The old Pearl Street station was started at 3 o'clock in the afternoon of September 4, 1882. Orders had been given that a circuit breaker of one of the Edison "Jumbo" dynamos should be closed at that hour, establishing, for the first time, connection between the station "bus" bars and the underground system, thereby formally inaugurating the service of the first central station in the United States equipped for the commercial supply of current for light, heat and power through a complete system of underground conductors and interior wiring.

At the offices of Messrs. Drexel, Morgan & Company, on Wall Street, were gathered a group of prominent financiers and enthusiasts centered around that interesting and original figure, Thomas Alva Edison. All were awaiting eagerly the "bursting into glory" of the incandescent lamps distributed throughout the offices, signaling the realization, at last, of the hopes and dreams of confident capitalists and enthusiastic disciples of the "wizard of Menlo Park."

To appreciate the enormous progress that has been made in industrial applications of electricity within the past 15 years, it may prove interesting and instructive to take a look into that historic station and examine the details of its electrical and mechanical equipment. No better idea of the status of the electric lighting industry at the time the Pearl Street station was opened for service can be given than by quoting the following extract from the first annual report of the Edison Company for isolated lighting, dated November 21, 1882:

"When this company was formed a year ago, the business of isolated lighting was entirely undeveloped, and no data existed whereby the future development of the business could be foretold. At that time Mr. Edison was making but one size of isolated dynamo, namely, the 'Z' dynamo (60 lights). We had no reliable steam engine; the innumerable details relating to installations, such as fixtures, safety catches and other appliances, were still unperfected, or were not manufactured on a suitable scale. There had been but eight isolated plants installed or in process of installation, and but one or two of them were in operation. We had no force of employees beyond a few connected with the New York office of the company, and but little preparation had been made for the development of the business. Such was the condition of the isolated business when the company was formed.

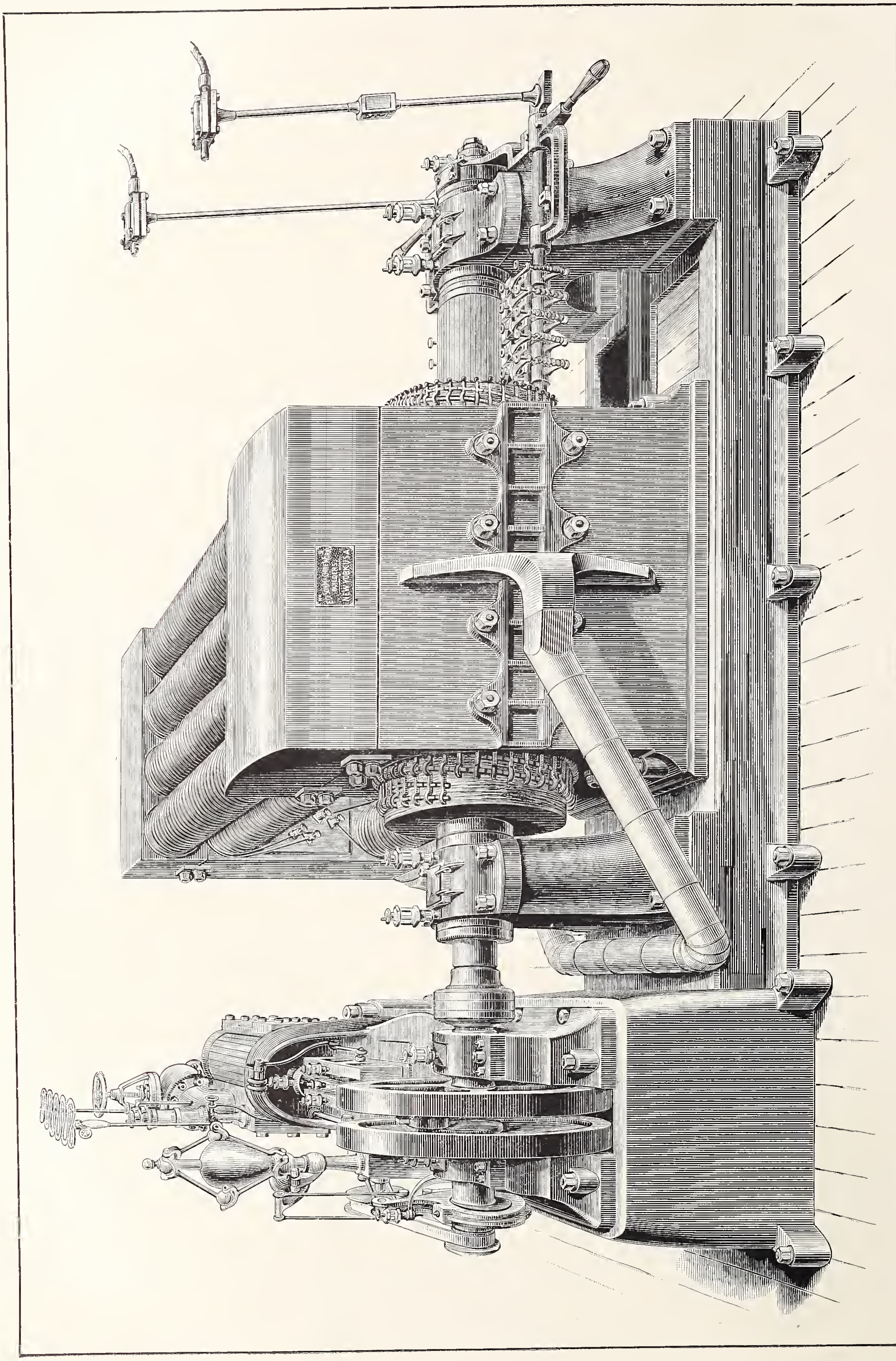
"One of the first things done by the company after its business had been systematized, was to take up the subject of procuring additional dynamos besides the 'Z' dynamos, and also suitable engines. At a meeting of the board of directors, held January 26, 1882, the subject of additional sizes of dynamos was discussed, and arrangements were made with Mr. Edison for the construction of experimental dynamos of additional sizes. The result was the production of two commercial dynamos in addition to the 'Z' dynamo, one being known as the 'L,' or 150-light dynamo, and the other as the 'K,' or 250-light dynamo. Arrangements are now being made for the construction of a still larger dynamo for isolated lighting, probably one of 350 lights. Regarding engines, great difficulty was experienced in obtaining an engine adapted to our special needs."

To that time—October, 1882—the company had installed in all 123 plants, with a total of 21,998 lamps. Among these were several of considerable size, and a few small central stations in country towns like Appleton, Wis.; Shamokin and Sunbury, Pa.; Brockton, Mass., etc., all of which were supplying current through overhead systems. Such was the state of the incandescent lighting industry when the Pearl Street station was about ready for operation.

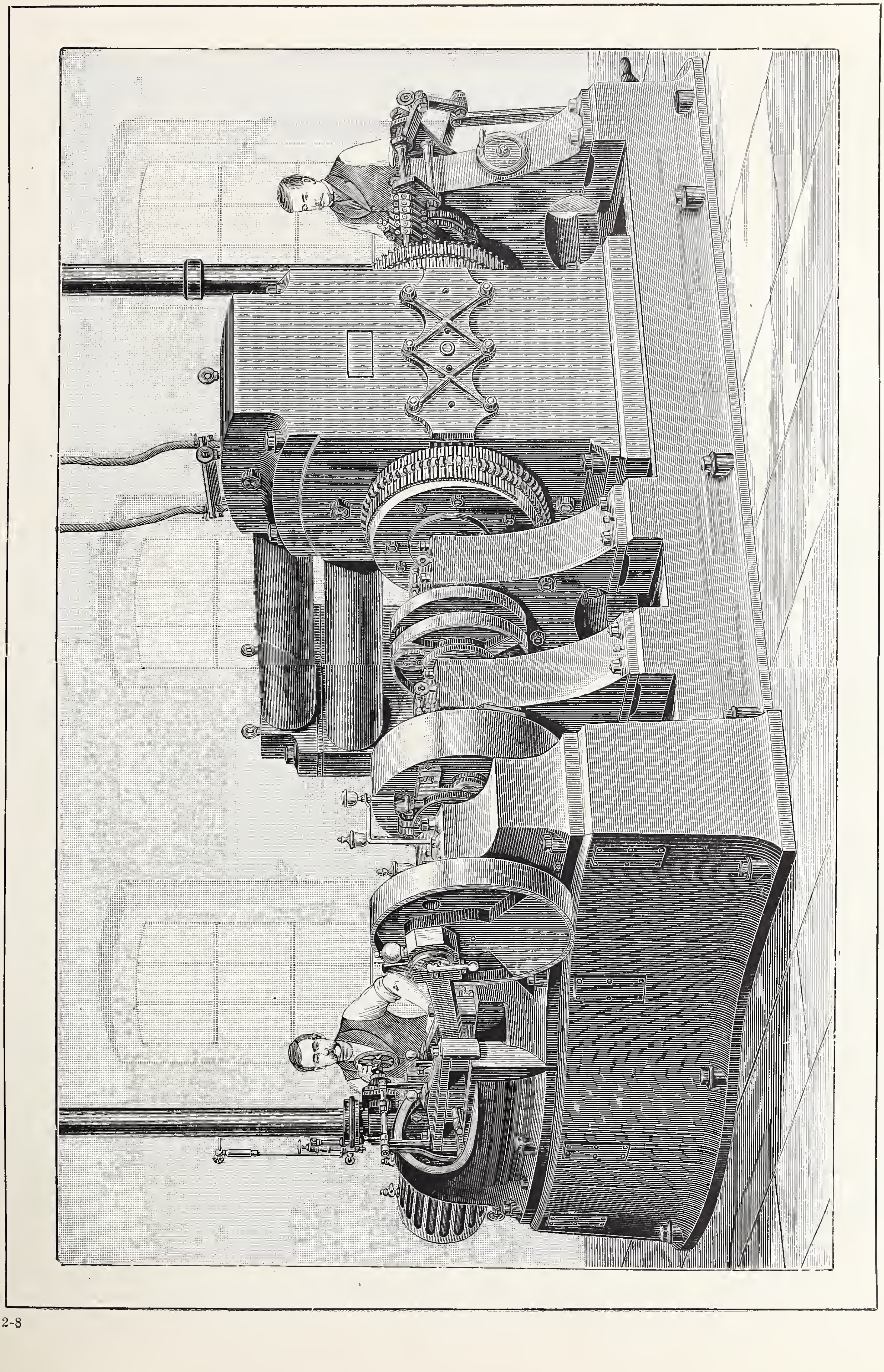
Fires were built under the boilers for the first time on June 29; the first dynamo was started July 5, and it was tested on a bank of 1,000 lamps in the station July 8. Then followed a period of tests and experiments which kept Mr. Edison and his assistants busy day and night, the public press meanwhile being filled with all kinds of wild rumors in explanation of the delay in lighting the district.

In examining the prominent features of this historic plant, we shall find, in one form or another, the essential elements of the best modern practice in central station construction. While it is true that some of the apparatus was crude and elementary in form as compared with present types, it amply demonstrates Mr. Edison's phenomenal anticipation of, and provision for, the broad lines which have made the Edison system so successful.

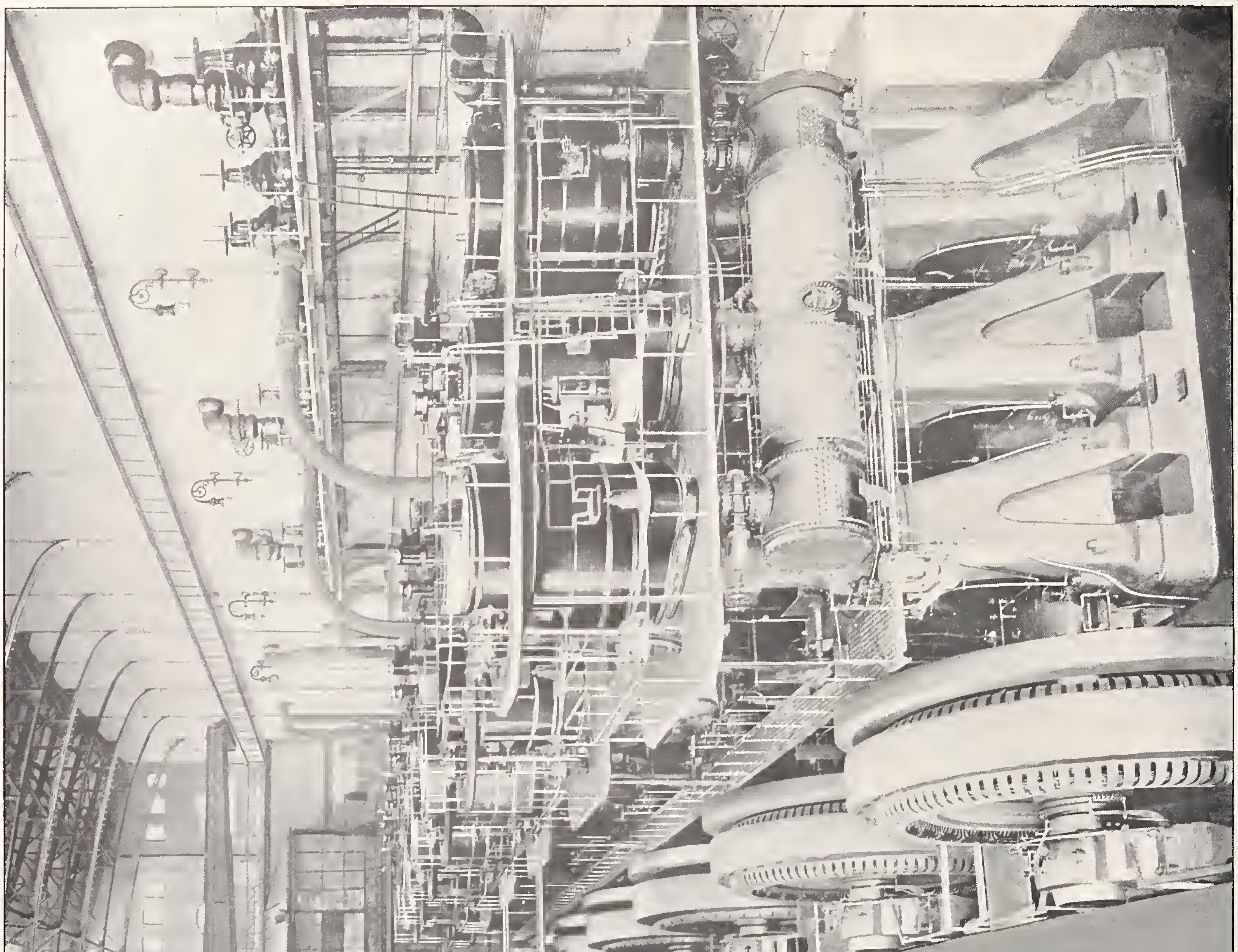
The station, as at first projected, occupied the premises 257 Pearl Street; 255, which was to serve for future extension, was temporarily used as a storeroom and shops for the



THE EDISON JUMBO DYNAMO OF 1881, USED IN THE HISTORIC EDISON PEARL STREET STATION IN NEW YORK. THIS WAS ONE OF THE FIRST EXAMPLES OF DIRECT-CONNECTED UNITS. THE ENGINE WAS A PORTER-ALLEN 200 H. P., RUNNING AT 350 REVOLUTIONS PER MINUTE, AND THE DYNAMO HAD A CAPACITY OF 750 AMPERES AT 120 VOLTS. EVENTUALLY THIS TYPE WAS REPLACED BY THE ONE SHOWN ON PAGE 73.



A LATER FORM OF EDISON GENERATOR, DRIVEN DIRECT BY AN ARMINGTON & SIMS ENGINE. THIS REPLACED THE TYPE SHOWN ON PAGE 72. THE ARMATURES OF THE JUMBO DYNAMOS WERE 27 INCHES IN DIAMETER, 61 INCHES LONG, AND EACH WEIGHED NEARLY 10,000 LBS. THE TOTAL WEIGHT OF THE COMPLETE UNIT WAS NEARLY 62,000 LBS.



A VIEW OF THE WATERSIDE STATION OF THE NEW YORK EDISON COMPANY, TAKEN IN DECEMBER, 1903

THE NEW WATERSIDE STATION OF THE NEW YORK EDISON COMPANY

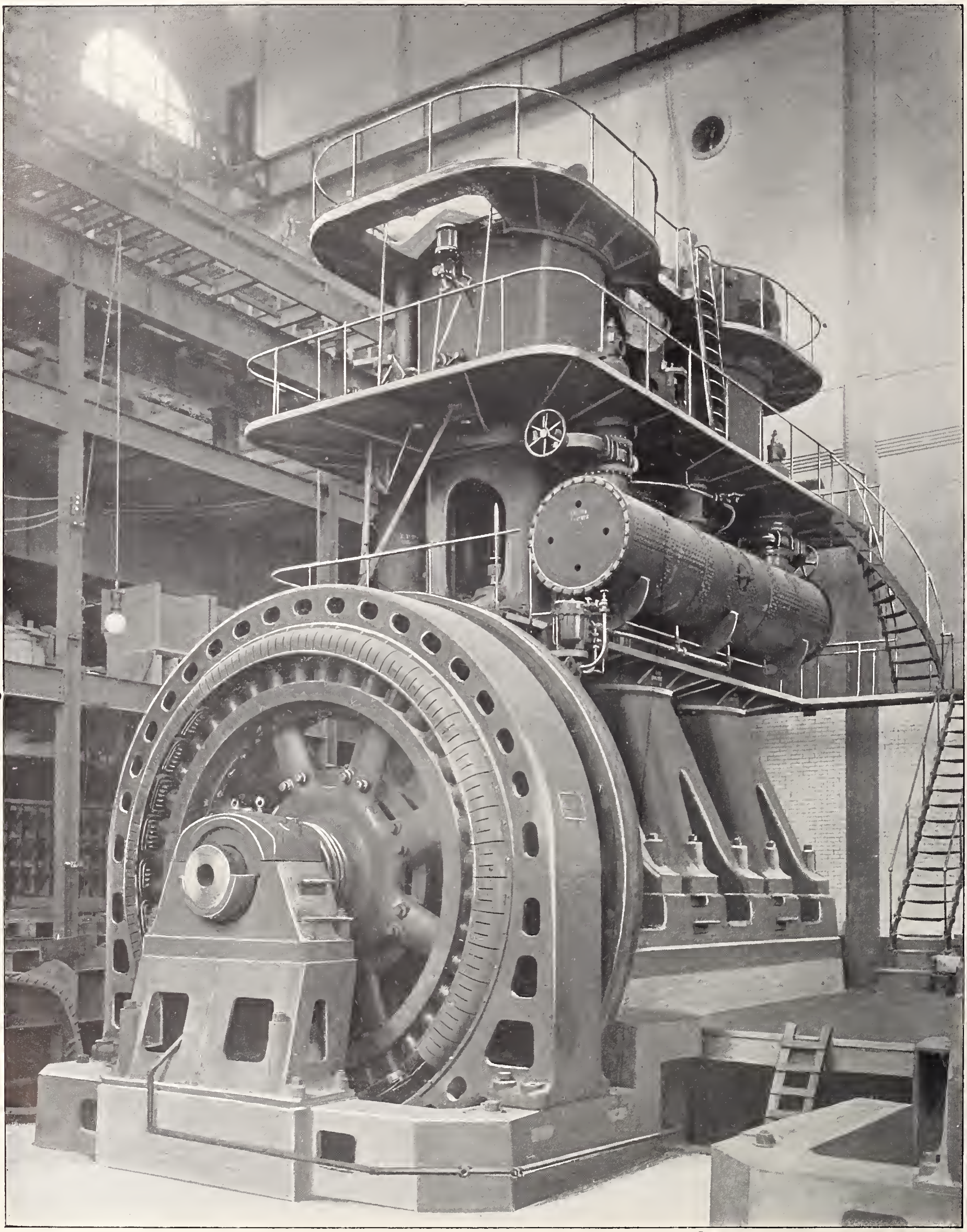
underground department. To prepare the building for the reception of machinery, a heavy iron structure of girders and columns, not unlike the elevated railway structure, was set up, the boilers being below, and the engines and dynamos resting on the girder platform above. The steam plant consisted of four Babcock & Wilcox boilers of 240 horse power each, with the necessary equipment of steam pipes, heaters and feed pumps; coal and ash conveyers and a blower for forced draught completed the equipment and auxiliaries. The engine equipment, as originally planned, consisted of six Porter-Allen engines, 11 1-16 inches by 16 inches, each of which developed a maximum of 200 horse power at 350 revolutions. The dynamos were of the old "Jumbo" type, one of the first examples of direct-connected slow-speed units, each having a capacity of 750 amperes at 120 volts when running at a speed of 350 revolutions per minute.

The conditions imposed upon the engines were so severe that but few engine builders dared attack the problem. High piston speed, close regulation, accurate balancing, limited space and great strength required to stand the sudden applications of load, made the use of the ordinary engine impossible. A number of types of engine were therefore especially developed for this work, at least two of which are still recognized in the market as standard types of construction.

In the preliminary tests of the engines and dynamos while under load, unexpected difficulties developed in connection with the operation of the steam dynamos in parallel. There was a continual tendency to shift the load from one engine to the other, a seesawing of the governors and great variations of speed, accompanied by brilliant pyrotechnic effects, that threatened the destruction of both engines and dynamos—a difficulty partially overcome by coupling the levers of the governors to a common rock shaft. Eventually Armington & Sims engines were developed, which completely solved this difficulty, and this type replaced several of the Porter-Allen engines.

The armatures of the "Jumbo" dynamos were 27 inches in diameter and 61 inches long, and each weighed nearly 10,000 pounds; the copper armature bars weighed 590 pounds and the armature disks 1,500 pounds. Each machine had 12 field magnets, of which 8 were connected to the upper pole-pieces and four to the lower; the copper wire on the magnets weighed 1,500 pounds, and the total weight of the magnetic circuit was something over 33,000 pounds. The base plate weighed 10,300 pounds, the dynamo 44,800 pounds, the engine 6,450 pounds, making the total weight of the complete unit 61,550 pounds. The progress made in dynamo construction since these machines—which were considered marvelous in their day—were built is shown by comparision with a modern slow-speed multipolar dynamo, which, of approximately the same capacity, weighs only one-fifth as much, occupies but one-third the floor-space, and has a much higher efficiency. The "Jumbo" dynamos heated seriously, and the commutators sparked viciously under full load, and it was necessary to use an air blast to keep the temperature down.

It will doubtless cause surprise to learn that the Pearl Street station was started and operated for some time without a single voltmeter or ammeter; in fact, the station switchboard, the central keyboard from which the modern station is controlled, was altogether absent in this case. The dynamo and distributing switches, field regulators, etc., were located without any attempt at centralization. The voltage was maintained with fair



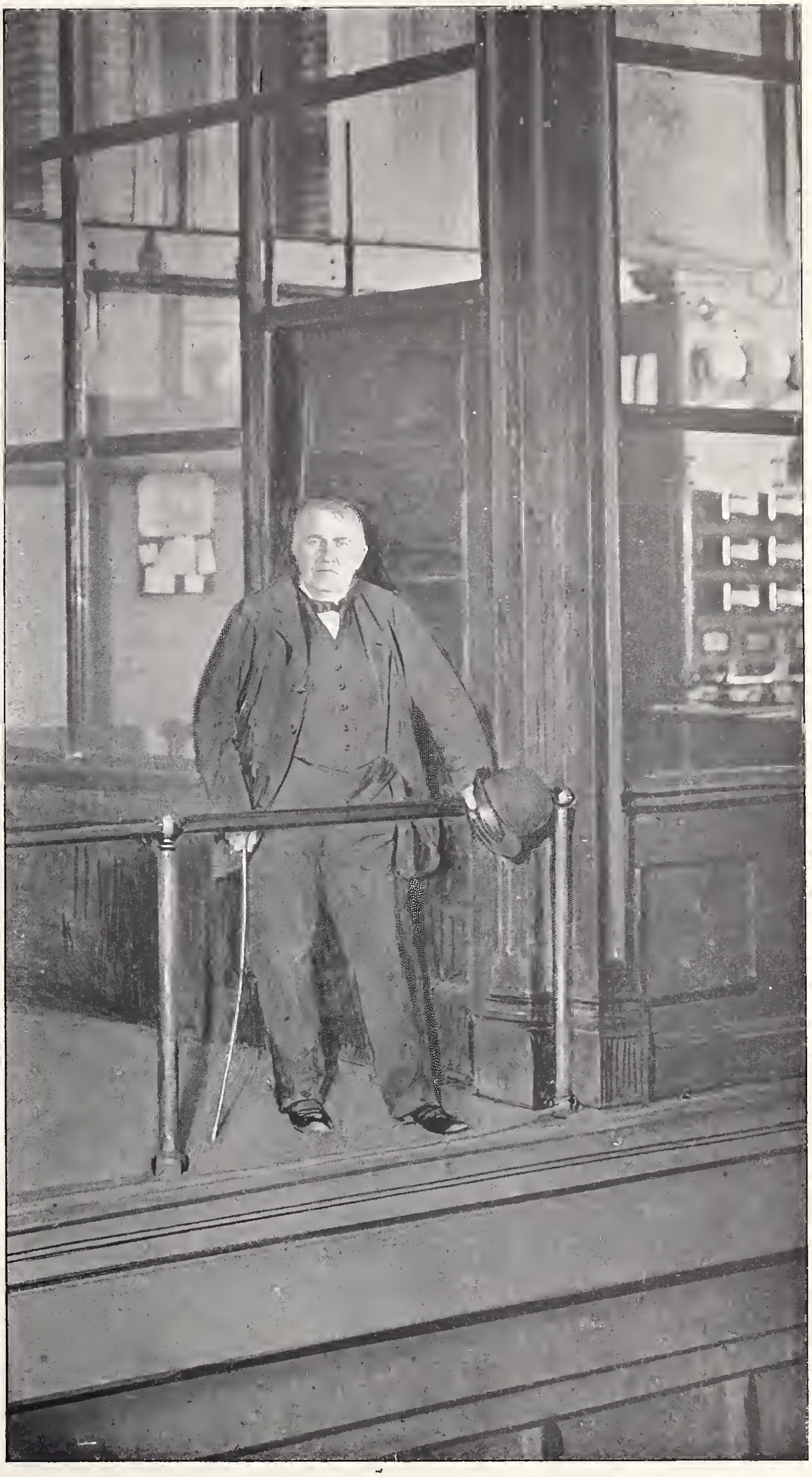
ONE OF EIGHT 3,500 K. W. 40-POLE ALTERNATING CURRENT, THREE-PHASE, REVOLVING FIELD GENERATORS BUILT FOR THE NEW WATERSIDE STATION OF THE NEW YORK EDISON COMPANY, BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., DIRECT-CONNECTED TO A WESTINGHOUSE COMPOUND ENGINE, WITH 43½-INCH HIGH-PRESSURE AND 75½-INCH LOW-PRESSURE CYLINDERS. STROKE, 60 INCHES. THESE ENGINES ARE DESIGNED FOR 5,200 TO 5,500 H. P. AT A MAXIMUM ECONOMY, AND CAN CARRY A LOAD OF 8,000 H. P. IF NEEDED

approximation from the indications produced by an electro-magnet connected across the circuit, the armature of which carried a contact lever playing between high and low contacts, the pull of the magnet being balanced against an adjustable spiral spring. These contacts closed a relay circuit having a red and a blue lamp, the red lamp lighting when increased voltage gave the pull of the magnet the ascendancy, and the blue lamp when the voltage dropped so as to give the spring the advantage. This apparatus was carefully graduated and adjusted by comparision with the electro-motive force of a standard battery.

The station "bus" bars were built up of the half-round copper bars of the Edison two-wire tubes, and the main dynamo switches—ponderous affairs, as big as hay-cutters—established connection between the dynamos and the "bus." The "bus" bars extended to the Pearl Street end of the station, and from this point copper lugs, carrying safety catches, distributed the current to the feeders entering the Pearl Street vault. The field regulators for each dynamo were built up of 40 or 50 large resistance boxes wound with strands of copper wire. They were so colossal that the regulators for the six dynamos, together with the connecting shaft and gear for operating the switch quadrants separately or together, took up nearly the entire floor above the dynamo room.

The underground system of mains and feeders—then of the two-wire system—had a length of about 18 miles. The territory supplied was about one square mile in area, extending from Wall Street to Spruce and Ferry Streets, and from Nassau Street to the East River.

The Edison underground tubes for the two-wire system differed from the present type in having two conductors of nearly semi-circular section, instead of three copper rods used in the three-wire system, and were separated by paraffined cardboard disks, instead of spirally-wound jute rope before filling with compound. The coupling joints of the 20-foot lengths were made of solid copper loops instead of stranded cable. At the time of laying the underground system, many of the tubes of large and small conductor section were bent by a special machine to the angle necessary to overcome the obstacles encountered in the streets, instead of using angle boxes, and many of the faults that developed in the early days were due to contacts in these bends.


THOMAS A. EDISON IN THE NEW YORK EDISON COMPANY'S WATERSIDE STATION

In laying out the first district and determining the number and location of the feeders, a model of the district was prepared to scale, small spools, with resistances proportioned to the number of lamps, indicating the number of important installations. Wires, representing the system of mains, were drawn along the block faces and connected at the corners, thereby forming a complete network. The location of the feeder connections was experimentally determined by actually sending current into the spools and wires and locating, by actual measurements with a galvanometer, the most favorable points of connection to give an approximately uniform distribution of potential over the system.

Much of the interior wiring was cleat work, and I am sorry to say that the dangerous iron staple was also in

evidence. Many of the first installations were equipped with wire having paraffined cotton braid insulation, but nearly all of this wire was replaced before the current was turned on the system.

From the beginning, Mr. Edison considered the meter one of the essential elements of a system for commercial supply of current for light and power, and, as soon as the station was started, arrangements were made to introduce the Edison chemical meter. The first bills based on the amount of current consumed, as shown by the meter, were rendered after the station had been in operation a few months.

The Edison lamps in use at that time were of 8 candle-power (two in series, of 50 volts each), 16 candle-power and 32 candle-power, with an efficiency of 4 2/3 watts per candle. On October 1, 1882—as stated, the station was started September 4,—59 customers, having an installation of 1,284 lamps, were connected; this number was increased on January 1, 1883, to 231 customers, with 3,477 lamps connected, and wiring had been installed for 5,328 lamps.

At the time the first lighting district in New York was canvassed, great importance was attached to the probable use of current to operate electric motors, and a map was prepared showing the location and capacity of all steam and power plants in the district. It was not until 1884, however, that motors were connected with the system. The first arc lamp was connected to the system in 1889.

Such was the old and historic Pearl Street station and the district it supplied, and such it continued, with slight additions and changes as experience was gained, and increased demand for current suggested improvements, until destroyed by fire in January, 1890.

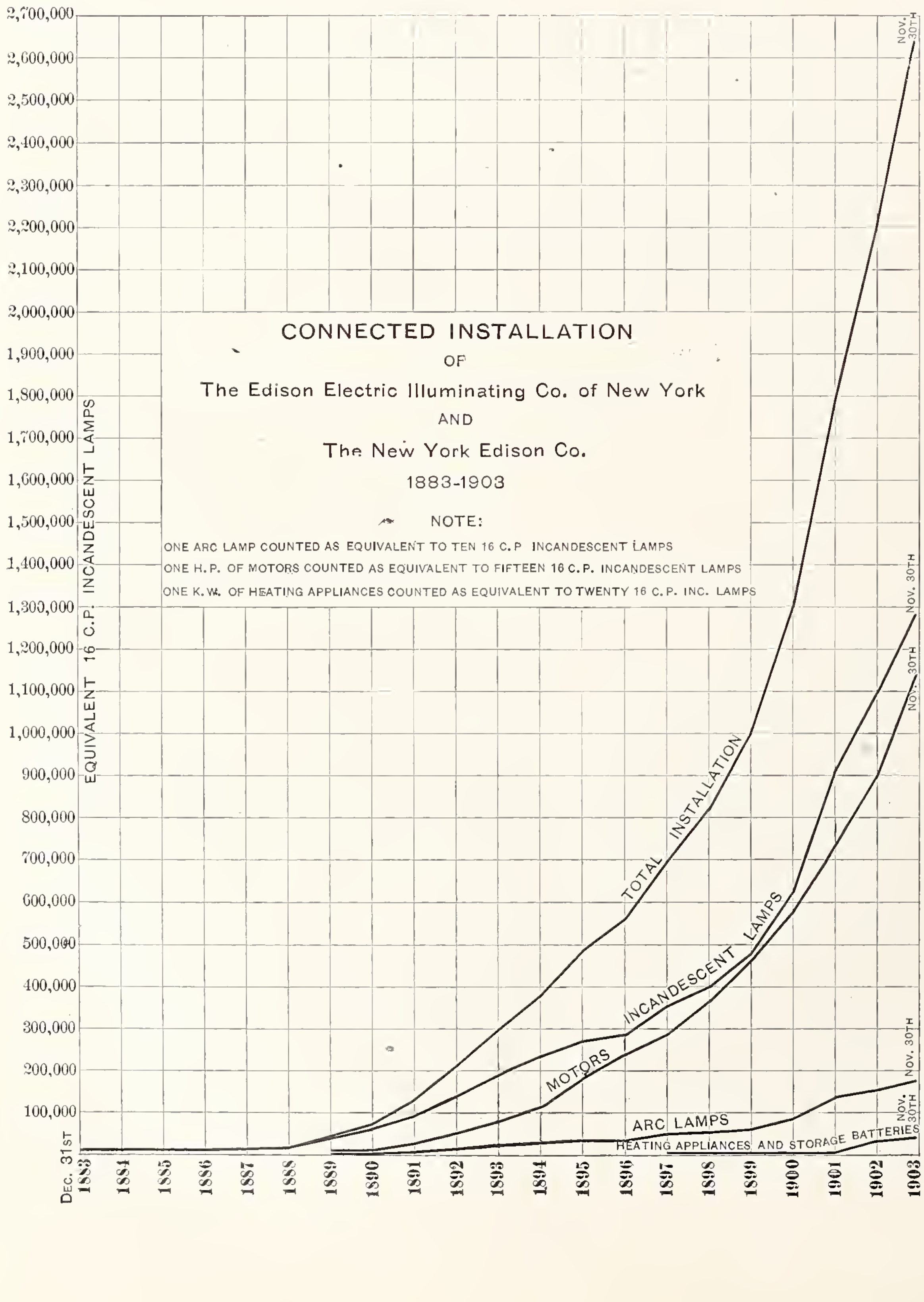
The writer will not dwell upon the other stations installed in New York during the period from 1882 to 1898, of which the Duane Street station, erected in 1893, was the most important, embodying such new features as a return to direct-connected units, vertical triple and quadruple expansion engines, 220 lbs. steam pressure, the edgewise switchboard system, and others, but will proceed at once to the consideration of the Waterside station of The New York Edison Company,—a typical modern power plant now rapidly approaching its full equipment.

The station is located on First Avenue, between Thirty-eighth and Thirty-ninth Streets, the rear facing the East River and covering an area 272 feet x 197 feet. The station is divided longitudinally into two parts, the main operating room 115 feet wide, and the boiler room in two stories, each 76 feet wide, above which is located the coal bunker with a capacity of 10,000 tons.

The present equipment consists of 56 boilers of the Babcock & Wilcox type, made by the Aultman & Taylor Machinery Company, of Mansfield, O., each boiler having 6,500 square feet of heating surface. Sixteen of the boilers are equipped with "Roney" stokers, the remainder with flat grates, a complete blower system supplying the forced draught, enabling the small sizes of anthracite coal to be used on the flat grates.

The generating equipment consists of eleven Westinghouse engines of the marine type, vertical, three-crank, with one high and two low-pressure cylinders, eight of them direct-connected to General Electric and three to Stanley three-phase generators. The high-pressure cylinders are $43\frac{1}{2}$ inches in diameter, the low-pressure cylinders, $75\frac{1}{2}$ inches, with a stroke of 5 feet, and with a speed of 75 revolutions per minute. The engines are designed to indicate 5,200 to 5,500 horse power at most economical load, with a maximum capacity of 8,000 to 9,000 horse power. The generators are of the revolving field type, 40 poles, generating 25-cycle alternating current at 6,600 volts, with a capacity of 4,500 kilowatts.

In addition to the eleven engines above referred to, there will be installed during the coming year a Curtis steam turbine, built by the General Electric Company, of Schenectady, New York, of a rated capacity of 5,000 kilowatts, leaving room for four more generating sets, bringing the total generating equipment up to approximately 75,000 kilowatts (rated). Current for field excitation is supplied by three 150-kilowatt motor-generator sets, the induction motors operating at



6,600 volts, and the generators delivering 300 volts.

In order to provide an adequate reserve against any interruption of the exciting current, the station is provided with a storage battery with a capacity of 8,000 ampere-hours, at a 10-hour rate at 135 volts; a second similar battery supplies current as a reserve capacity to the local distributing plant.

The station has a complete equipment of coal and ash-conveying apparatus for receiving coal from the bulkhead and delivering it to the bunkers, and for discharging ashes into scows on the water front. The station serves also as a distributing station for the territory between the East River and Third Avenue, from Twenty-third to Forty-second Streets, three 500-kilowatt motor-generator sets transforming current for distribution to the direct-current low-tension Edison three-wire system.

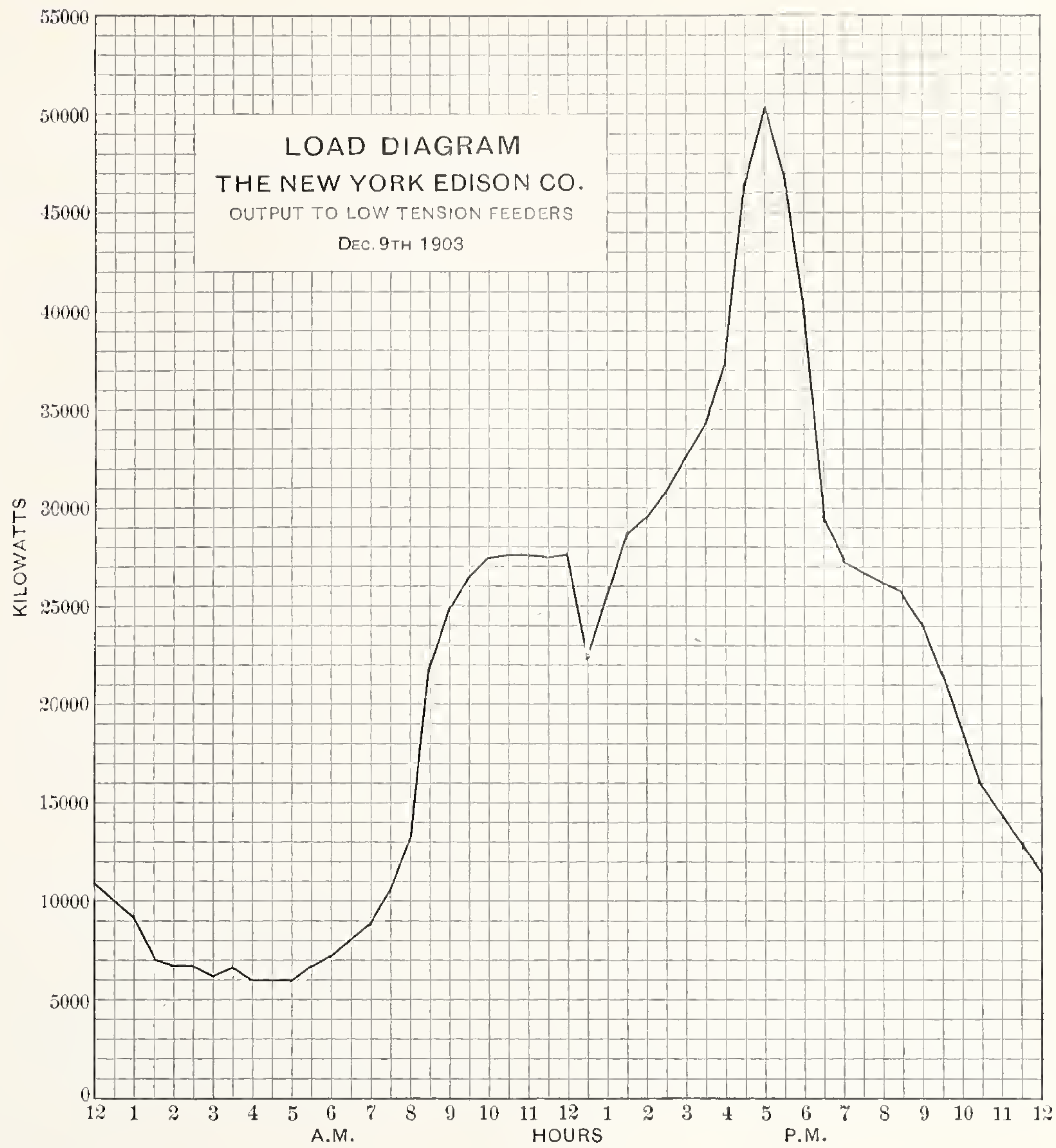
The high-tension current leaves the station by fifty high-tension, three-phase feeders, each conductor having a copper section of 250,000 circular mils. These feeders distribute current, many of them by alternate routes, to twenty annex stations, from which current is sent out either as low-tension direct current or as high-tension 60-cycle alternating current.

It is unnecessary at this time to go into details as to the distributing systems, as these have been referred to many times previously.

The diagram on the opposite page gives some idea of the rate of progress made in electrical applications in New York City, from the insignificant installations as supplied from the old Pearl Street station, when it was first started, as previously mentioned, to the installation equivalent connected to the system as indicated on the diagram on November 30, 1903.

On that date there were connected to the Edison system on Manhattan Island 1,396,848 incandescent lamps, 16,337 arc lamps, 2,150 kilowatts in storage batteries and heating appliances, and 76,873 horse power in motors,—a total of 2,707,320 sixteen candle-power equivalents.

Some idea of the current necessary to supply this installation may be obtained from the diagram on this page, which shows the low-tension direct-current output delivered to the low-tension feeder system on one of the days of heavy load during the past year.



The above installation figures by themselves afford but a limited idea of the extent to which the central station electricity supply has entered into the industrial and social life of the community. The myriads of lamps visible in stores, shop windows and in flaring electric signs, are a conspicuous evidence of the many applications of central station service, and afford an index of the very general use of electricity in catering to the pleasure and convenience, as well as the needs, of the public.

The Theory of Radium

In an interesting lecture on radium, delivered at Birmingham, England, a short time ago, Sir Oliver Lodge, the speaker, claimed that although when the X-rays were discovered theory was for a moment behindhand, this was not the case with radium, since the theory of bodies of this kind had already been worked out. This theory is due to the labors of many, but to two investigators in particular, in Sir Oliver's judgment, namely, Messrs. Larmor and Thomson, now professors of mathematics and physics, respectively, at Cambridge.

From them and others we learned, the lecturer said, that electricity existed in small particles, which could, in a manner, be "seen" in the cathode or Crookes' rays, and which were called electrons. These compose the atoms of matter. Atoms are small; three hundred million of them could lie in a row side by side in an inch. But electrons are very much smaller, 100,000 of them could lie in the diameter of an atom, for they are a thousand million million times smaller in bulk than atoms are. An atom of matter as near as can be estimated at present, consists of positive and negative electricity, and nothing else; the negative electrons in a state of violent movement, with occasional possibility of escape. An electric charge in motion constitutes all the electric currents and magnetism, and it possesses momentum; further, when accelerated, it should, by Poynting's theorem, generate radiation.

Hence, on the view, or mathematical theory, that the atom is actually so constituted, the absence of atomic radiation in 1895 was a difficulty; the escape of the electrons as projectiles was probable; and soon afterwards it was realized that, since the atom was composed of parts, the occasional disintegration of an atom was not unlikely. These three expected effects have now been experimentally observed in the radiation from two or three different elements, and constitute what are called the gamma rays, the beta rays, and the alpha rays respectively.

A branch of the American Institute of Electrical Engineers is to be formed at Atlanta, Ga.

Syntonic Aerography

By LEE DE FOREST, Ph. D.

MUCH has appeared in the technical and popular press concerning the question of interference between a number of wireless telegraph stations when operating simultaneously, and the possibilities of preventing such interference. Yet, notwithstanding, and possibly because of the variety of conflicting opinions and explanations given, much misunderstanding on this subject is in evidence.

It has again and again been shown how it is possible for two wireless transmitters, each sending out Hertzian oscillations of a frequency differing sufficiently from that of the other, to excite two distinct receiving systems, each tuned in syntony with its own transmitter. This is easy to accomplish provided first that the two wave-lengths employed are sufficiently unlike, and, second, that neither transmitter acts too powerfully upon that receiving instrument with which it is not desired to communicate. The old thread-bare analogy explains it very simply. If one lifts the dampers from the strings of a piano and sings loudly one clear, long-sustained note into the instrument, he will hear a faint response from the string attuned to that note, and possibly also from its first, or even second, octave string. Sound similarly another note, and the same effect is noted from another and corresponding string. But let one sing the note very faintly for a fraction of a second only, and he will not find his string responding; conversely, let him shout loudly, even a clear note, and most, if not all, of the strings will take it up to some extent; let him strike the body of the piano a quick, strong blow, and every string vibrates violently.

It is exactly analogous in wireless telegraphy; the simple tuned receiver, as now generally understood, depending for its resonant quality upon the self-inductance of a coil of wire and the capacity of a condenser in circuit with its wave detector, is absolutely at the mercy of a pure tuned wave of whatever frequency, provided this be of sufficient power when it reaches the receiving antenna.

It is, of course, possible to cut in a resistance in this receiving antenna, and to diminish the strength of the impulses received from the offending transmitter so that these are no longer able to excite oscillations in a local resonant circuit which is attuned to quite another frequency. But at the same time it is to be remembered that this inserted resistance must also cut down the effect of the oscillations emitted by the transmitter which is in tune with this receiver, and which it is desired to hear. Consequently, if this latter instrument be less powerful than the hostile transmitter, or further removed, it is impossible by the existing methods to receive its messages free from interference.

The same considerations hold yet more strongly when the source of interference is practically an "a-periodic" transmitter, or one giving out not a succession of uniformly timed impulses, *i. e.*, a train of waves, but simply a single, violent, etheric blow; a "whip-crack," instead of the musical note.

DR. LEE DE FOREST.

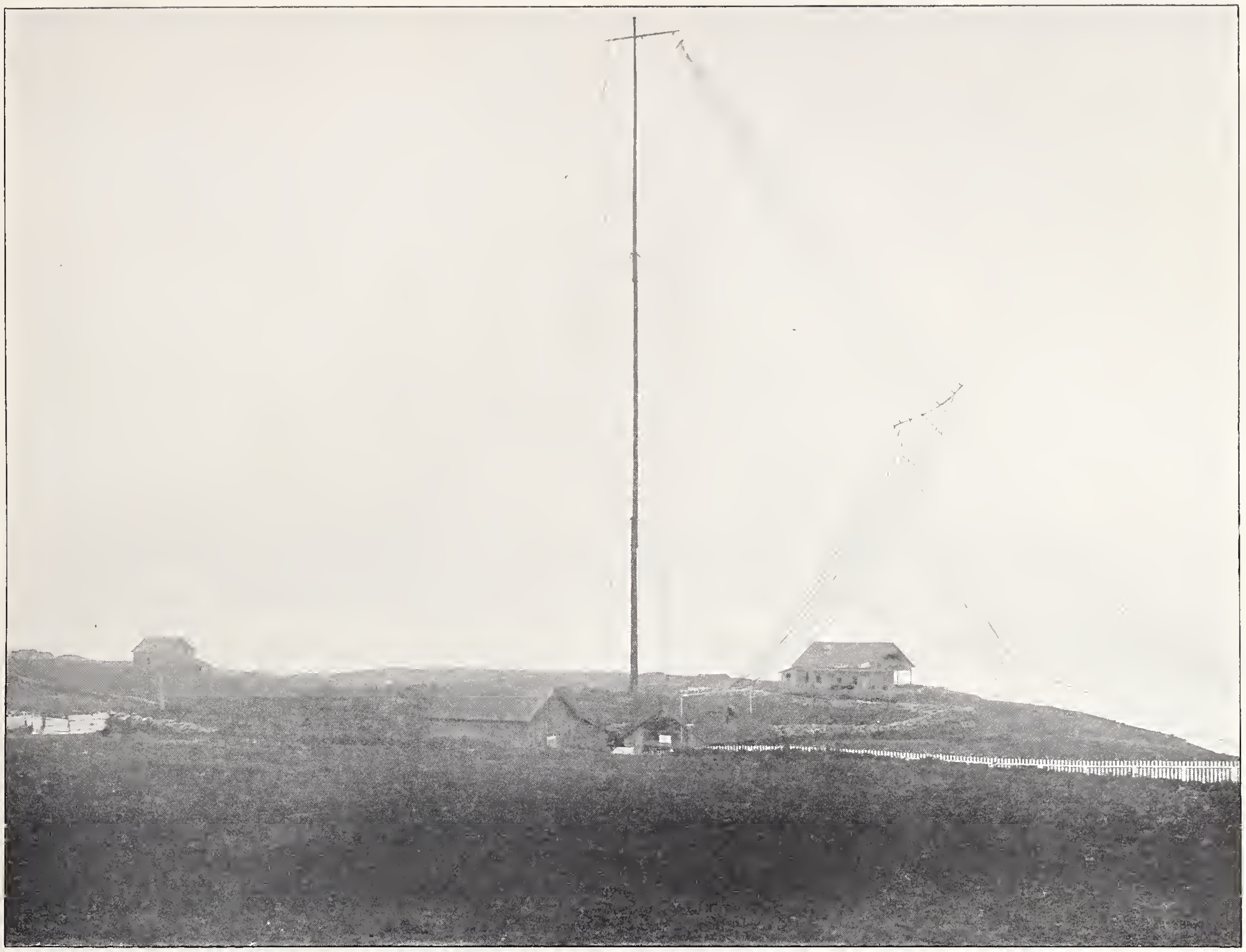
Photo by the Falk Studio, N. Y.

There is, however, a method of protecting a tuned receiver from all influences of this character, and rendering it strictly deaf to any but prolonged wave-trains of its own, or nearly its own, attunement; and I have little fear that the present vulnerability of the so-called protected or syntonic receivers to violent hostile impulses will long exist. Theoretically, this method will make a receiver immune even from the impulses of a powerful transmitter at the same station and utilizing the same antenna wires, but for actual duplex working, additional precautions are necessary.

Before the above method of preventing interference from strong a-periodic impulses is practical for commercial working, a number of details must be refined, and I hope before long to be able to disclose the *modus operandum* of this invention, realizing that to-day nothing in wireless telegraphy will be more useful, or is awaited with keener interest by technical men.

Another desideratum in syntonic aerography is the production of longer wave-trains, *i. e.*, that each spark shall represent, not as it generally does today, a train of three or four impulses rapidly dying away, but one entailing ten or twenty complete oscillations. This effect will not, as some might suppose, necessitate slower word-transmission, for the actual duration of such long wave-trains, even with wave-lengths of many hundreds of feet, is to be computed in ten-thousandths of a second. Thus, if the length of a radiated wave is 1,000 feet, a wave-train of twenty complete oscillations, which may be classed as one but slightly damped, is about four miles in length, and 46,500 such wave-trains per second could be sent out, were it possible to obtain so great a spark frequency. But with the spark frequencies actually obtainable and desirable, say 200 per second, it will be seen that intervals of no radiation exist between sparks which represent more than two hundred times the duration of the actual period of radiation. To obtain then an absolutely undamped train of waves would require the generation at each spark of a succession of some two hundred more oscillations than the ordinary oscillating transmitter circuit (containing Leyden jars, inductance helix, and spark gap) will now maintain.

If a hot-wire ammeter, suitably shunted for its own protection, be inserted in the antenna or ground wire of a transmitter taking about two horse power, it will show a reading of three or four amperes, when the in-



THE BLOCK ISLAND DE FOREST WIRELESS TELEGRAPH STATION. A TYPICAL INSTALLATION

ductance in the closed oscillating circuit, to which the antenna and ground are attached, is so regulated that this circuit is "in tune" with the antenna's natural period of vibration. But this same hot-wire instrument, if placed in the oscillating circuit itself, will show a reading twenty or even fifty times as great. This merely goes to prove how small a part of the available energy is actually sent into the antenna and radiated outwards. Were it possible to get a reasonable efficiency of transfer of energy from the oscillating circuit to the aerial we might well expect such a transmitter as the above to operate over the Atlantic Ocean. One fact must be borne in mind here, however; the antenna system is poorly resonant compared with the closed oscillating circuit. It is strongly damped, and therefore a good radiator, and a hot wire inserted there is by no means subjected to the same cumulative heating effect of the current passing to and fro through it as it is by the same number of amperes if the instrument be located in a closed, strongly resonant, oscillating system. The exact quantitative determination, or comparison between the cumulative current effects in antenna and oscillator respectively, is extremely difficult, and theory gives us little data of real value as a basis for such comparisons.

Nothwithstanding all that has been said concerning the great inefficiency of the ordinary spark in air and the large amount of damping of the oscillations thus resulting, with a spark from a battery of, say, ten two-quart Leyden jars in parallel, and not exceeding an inch in length, kept clear of all arc or flame, the oscillations are well prolonged, and if no radiating antenna and earth are attached to the circuit, the latter cannot be styled strongly damped.

Placing the spark-gap under heavy air compression undoubtedly diminishes the damping there resulting; any such method for shortening the spark length, while maintaining the sparking potential, will have this effect. But what is most needed is a closer linking of antenna and oscillating circuits—a more equitable proportioning of the respective amounts of energy in the two.

The current amplitudes in the antenna circuit do not approach those in the exciting and feeding circuit. Here I obtain the best results with the autotransformer connection, *i. e.*, by making a portion of the helix at the base of the aerial actually a part of the oscillating circuit, so that this same helix comprises the greater part of the inductance in the oscillating circuit. The same principle is used by Professor Slaby. It allows greater current densities in the aerial than I have been able to obtain with any transformer of two distinct and insulated windings. The linking between the resonator and radiator circuits is much more intimate, and the antenna therefore more readily takes up the forced vibrations. This latter is a valuable feature; for transmission is invariably better with long wave-lengths of oscillation, and practical considerations render it generally impossible, where any quantity of energy is to be radiated, to employ antennae whose natural periods of vibration are equal to those of the feeding, or oscillating, circuits. In such a case, the best that can be done in attuning the two is to choose an oscillating circuit for which the natural

period is a lower harmonic of the natural period of vibration of the antenna circuit, and then to so closely link the two circuits that the antenna circuit is forced to vibrate in pulse with the oscillations of the closed resonator circuit.

The natural quarter-wave-length of the antenna's natural vibration may be made to be very different from that of a simple straight wire of the same length and height. Thus it is common to assume that an antenna consisting of one wire 200 feet in height sends out a wave 800 feet long; but by actual measurement of the natural period of an antenna consisting of ten wires, each 200 feet in length, connected at top and bottom, supported by a mast only 180 feet in height, and spread out widely midway up, in fan shape, a quarter-wave-length of 287 instead of 200 feet was obtained, an increase of 43 per cent. This increase in the natural period of vibration was partially due to the additional capacity, with respect to earth, which such a flare fan-shaped arrangement of wires produced. It was found that this natural period of vibration varied somewhat from day to day, in a peculiar, and as yet unexplainable, manner, due probably to variations in the moisture in the earth and air; and this irregularity—almost invariably found to exist with any antenna—is another weighty reason why it is impossible to depend much on the natural period of the elevated radiating conductors for tuning, but advisable rather to force the antenna always to vibrate strongly to the period of the resonator circuit, where the determinating factors may be kept practically constant.

The same considerations hold for the receiving system; the antenna should serve simply as a collector of neutral periodicity; in other words, be so strongly damped that the period of the received oscillations which it collects and transmits to the resonant receiving circuit at its base shall not be affected by such vibrations as from day to day occur in the natural period of vibration of the antenna.

By this means we virtually obtain a closed resonant circuit at the transmitter operating upon a closed resonant circuit at the receiver through the medium of two neutral antennae, and strong response is obtained only when the resonant circuit of the receiver is in close syntony with that at the transmitter.

It has been abundantly pointed out that syntony is very unsatisfactory unless the resistance and capacity of the receiver itself are always the same upon the receipt of the transmitted impulse. This, unfortunately, is not the case with any coherer, microphone, or auto-coherer. In the filings tube the great variant is the capacity, which is surprisingly large; in the microphone the resistance, which is considerable, varies widely from time to time. As a result, the natural period of the resonant receiving circuit is constantly altering, and close tuning with the same is therefore impossible.

A DETAIL OF THE BLOCK ISLAND DE FOREST STATION

In the form of electrolytic responder which I am now using I find these elements of resistance and capacity surprisingly constant. If the electro-motive force of the local battery as applied to the responder is not too great, a delicate galvanometer in the circuit shows a constant reading, and its deflections, which are exactly proportional to the strength of the received impulses, are not capricious or irregular, as is frequently the case where an auto-coherer is employed. As a result of this regularity it is possible to obtain far better results in electrical attuning than with any form of coherer or any practical wave detector with which I am acquainted, save possibly the magnetic detector; and at present there is no comparison between the sensitiveness of this electrolytic responder and that of the detector.

A bit of electric railway enterprise, credited to a company somewhere in Illinois, is the rigging up of a portable electric motor for the use of the farmers in the district through which the line runs. Whenever one of them wants power to run a threshing machine, shedder, wood cutter or other machinery, the motor will be sent along on application and connected up with a portable wire connection to the lines of the railway.

Electrical and Mechanical Progress

The Woodward Water Wheel Governor

THE best modern practice in electrical engineering, as regards both steam and water power plants, is to install as large generating units as practicable. In water power plants, provision for this is sometimes made by mounting several turbines on one shaft, or where the head is too low to permit of this, several turbines are geared to one common horizontal shaft to which the generators are direct-connected.

It is for installations of this character that the Woodward Governor Company, of Rockford, Ill., have designed their horizontal model, compensating type, water wheel governor, of which several illustrations are given on this page and the one following. Fig. 1 represents the governor complete with its accessories; Fig. 2 explains the controlling mechanism; and Fig. 3 shows the governor connected up in an existing plant.

Power to operate the governor is taken from the main driving shaft by belt, the governor pulley shaft, as a reference to Fig. 1 will show, carrying a double beveled friction wheel, through which the power to operate the gate is applied. On either side of this friction wheel, which is made of compressed paper, are friction pans, with beveled surfaces fitting those of the wheel, one pan being for opening and one for closing the gates. These pans are pressed into the hubs of pinions which are loose on the shaft and engage with the gears on a back shaft, one directly and the other through an intermediate gear, thus giving reverse movements. The pinions are held in position by flanges on their hubs, which are engaged by overhanging lips on the bearing bushings. The proper clearance between the pans and the friction wheel is maintained by adjusting collars threaded onto the bearing bushings and seated in recesses in the main bearings.

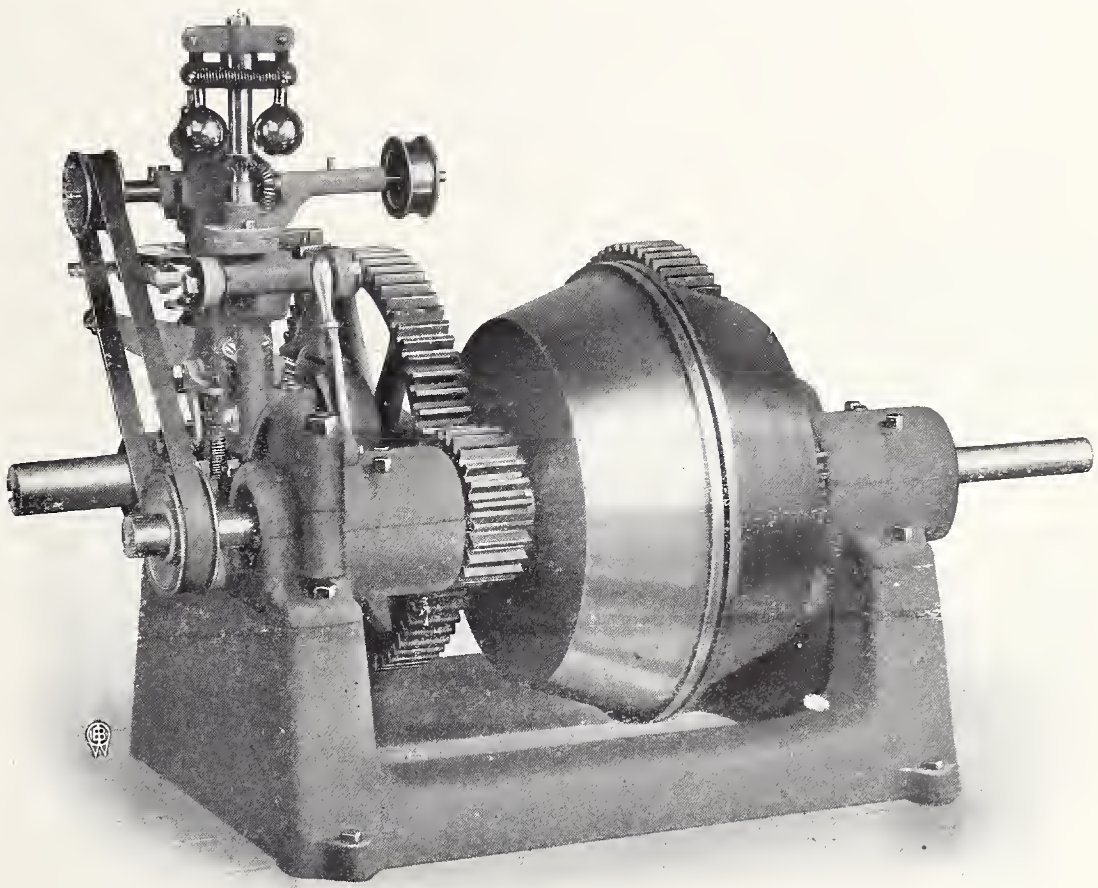


FIG. 1.—HORIZONTAL MODEL, COMPENSATING TYPE GOVERNOR, MADE BY THE WOODWARD GOVERNOR COMPANY, ROCKFORD, ILL.

A thrust collar is attached to the shaft, and by it the paper friction wheel is forced against one of the friction pans whenever it is necessary to open or close the gates of the water wheel. Over this collar is fitted a fork, attached to the controller lever and operated by a crank on the controlling mechanism.

The main bearings are ring oiling, and from them an ample supply of oil is carried by spiral grooves through the hubs of the spur pinions and returned to the oil reservoir through holes in the hubs of the pinions. To prevent oil from the bearings reaching the friction surfaces, oil pans are provided to catch any that may work along the shaft.

The controlling mechanism, shown in Fig. 2, is mounted on an upright

standard attached to the main frame. The fundamental parts of this mechanism are:—A constantly revolving double-faced cam; an upright rock shaft so connected with the main friction shaft that the latter is forced endways when the rock shaft is turned, this shaft having pivoted to it a frame carrying tappets adapted to be operated by the cam; a speed governor to control the position of the tappets with reference to the cam; and a compensating device to limit the action of the speed governor to compensate for the time required by a change of gate to overcome the momentum of the machinery.

The cam is driven continuously by spiral gears and a belt from the main friction shaft. Both the cam and the tappets are made of the highest grade tool steel, carefully hardened and tempered, and are very durable. The tappets slide in pockets in the ends of the tappet arms and are held inwardly by flat springs. These cause the friction wheels to be engaged quietly and without jar; their strength and action regulates the pressure applied, and thus the power which the governor will transmit to the water wheel gates.

On the lower end of the rock shaft is a crank working between the plates attached to the sides of the controlling lever. This lever is pivoted in a socket attached to the main shaft bearing and carries a fork fitting over the thrust collar on the main shaft. By throwing the lever back the plates may be separated so that the crank will not act. The gates may then be opened or closed by hand.

The speed governor used is of the high-speed spring type, is very sensitive, and owing to the manner in which the balls are suspended, is not affected by the vibrations of other machinery. It is separately driven from the water wheel or line shaft. The speed governor rod rests upon the top of the tappet frame, pressing downwards upon it as the balls are thrown outwards by centrifugal force. To support the tappet frame against this downward thrust, another rod passes down through the hollow rock shaft and is supported by a speeder spring on the side of the controlling standard. When the speed is normal the downward thrust of the speed governor is just balanced by the upward thrust of the speeder spring. This supports the tappet frame so that the cam may revolve freely between the tappets without touching either. A limited adjustment of the speed can be made while the governor is in operation by varying the tension of the speeder spring with the thumb nut.

Any variation from the normal speed moves the tappet frame and brings one of the tappets against the cam. The tappet is forced outwards, turning the rock shaft and causing the proper friction wheel to be engaged to open or close the gate as is needed. It is necessary, however, that the movement be checked when the gate has been moved the right amount, as this will be accomplished before the speed fully returns to the normal, some time being required to overcome the momentum of the machinery. This result is very accurately obtained by means of the compensating device.

On the lower end of the cam shaft is a friction disk, which rests on a rawhide friction wheel on the diagonal shaft. The hub of the friction wheel is threaded and fits loosely on the diagonal shaft. The constant tendency of the rotating disk is to cause the friction wheel to travel along the shaft to a normal position at the center of the disk. When the governor moves to open or close the gate, the diagonal shaft, which is geared to it, is turned and the friction wheel is caused to travel along the shaft, away from the center of the disk, and to raise or lower the cam shaft. As soon as the gate movement ceases, the disk causes the friction wheel to gradually return to the center and the cam shaft to resume its normal position. The movement of the compensating wheel is upward as the gate is opened, and downward as it is closed, and always tends to separate the cam from the tappet which is in action.

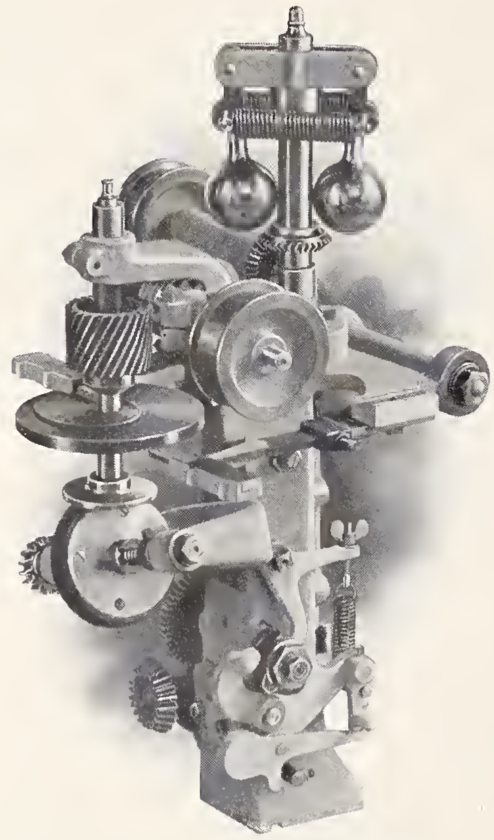


FIG. 2.—CONTROLLING MECHANISM OF THE WOODWARD GOVERNOR

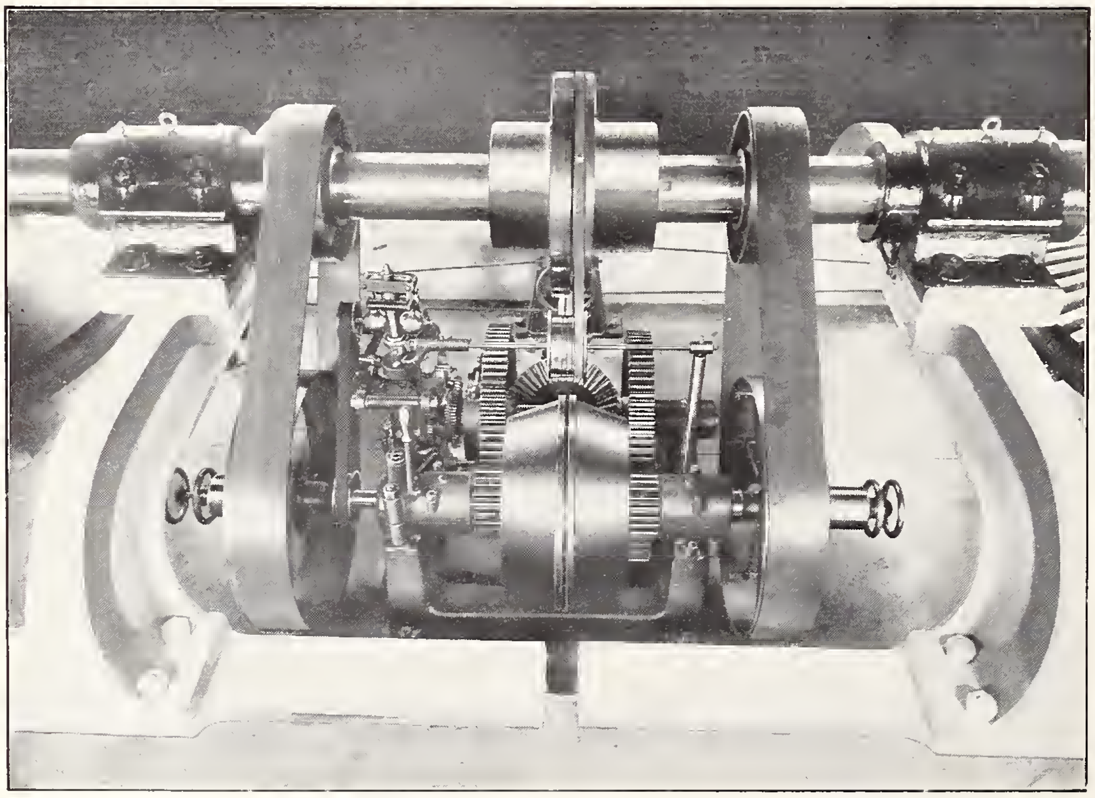


FIG. 3.—WOODWARD GOVERNOR IN THE ROCK ISLAND ARSENAL POWER HOUSE, CONTROLLING WHEELS WHICH DRIVE ALTERNATING-CURRENT GENERATORS RUNNING IN PARALLEL

Stops are provided to prevent further effort when the gates are full open or closed. These stops may be set to act at any point desired. A safety stop is provided which will close the gates should the speeder belt break or the balls be stopped from any cause. In some plants the full opening of the gates, which would otherwise occur, would be less objectionable than closing them, and when such is not the case this stop need not be used.

Where there are several governor controlling wheels which are attached to the same shaft, or which drive alternating-current generators running

in parallel, as in Fig. 3, a simple equalizing device is provided which causes the governors to maintain the same gateage, thereby distributing the load equally among the wheels.

Motor-Operated Valves

It is only about three years ago that the idea of using electric motors for opening and closing large valves was first seriously considered. Previous to this, electric motors had probably been used in a few isolated cases, but no one had undertaken to install or design a large system of valves to be operated by them. To Mr. Gustave Bouscaren, of Cincinnati, Ohio, who as chief engineer of the Cincinnati Waterworks Commission has designed and built one of the most extensive and up-to-date waterworks and filtration plants in the country, belongs the honor of first having designed a plant of this kind, where electric power alone is used for operating a large number of valves.

Mr. Bouscaren, in conjunction with engineers of the Coffin Valve Company, of Neponset, Boston, Mass., and the Northern Electrical Manufacturing Company, of Madison, Wis., went carefully over the ground and considered every point and every difficulty to be overcome in connection with using electric motors for this purpose. The result of their work is a system of power transmission and motor and valve control which is claimed to have been found very satisfactory.

Under this system of valve operation the motor is geared direct to the valve mechanism and is always ready for operation. The motor can be started at a central point, and any distance from the valve without necessitating the presence of any one at the valve. A few small wires constitute all the connections between it and the station. There are no packings to dry up during inaction and to leak when the valve is being opened or closed, as when hydraulic power is used; and there is no water to freeze in the winter time, or oil to drop into the water mains and pollute the water supply, as is the case when oil is used as a substitute for water to avoid freezing.

It is important that the fewest possible auxiliary parts be used in applying the motor to the valve, for if a large train of gears with bearings, shafts and supports must be used in order to obtain the proper speed reduction from the motor to the valve, the whole combination is apt to become clumsy and expensive. The very slow speed at which the valve must move necessitates either a very slow-speed motor or some mechanical reduction inserted between the motor and valve mechanism. A motor running at a low enough speed to permit eliminating the intermediate gears, would have to make not more than about 150 revolutions per minute, and such a motor would be objectionable for several reasons. It would be about four times larger and cost about three times more than a motor running normally at, say, 750 revolutions and its efficiency would be considerably less. If a train of gears be inserted between the motor and the valve mechanism, there would have to be bearings, shafts and supports, mounted on the valve standard, involving considerable additional cost in constructing, and such a standard, besides, would make the whole outfit clumsy and of special construction.

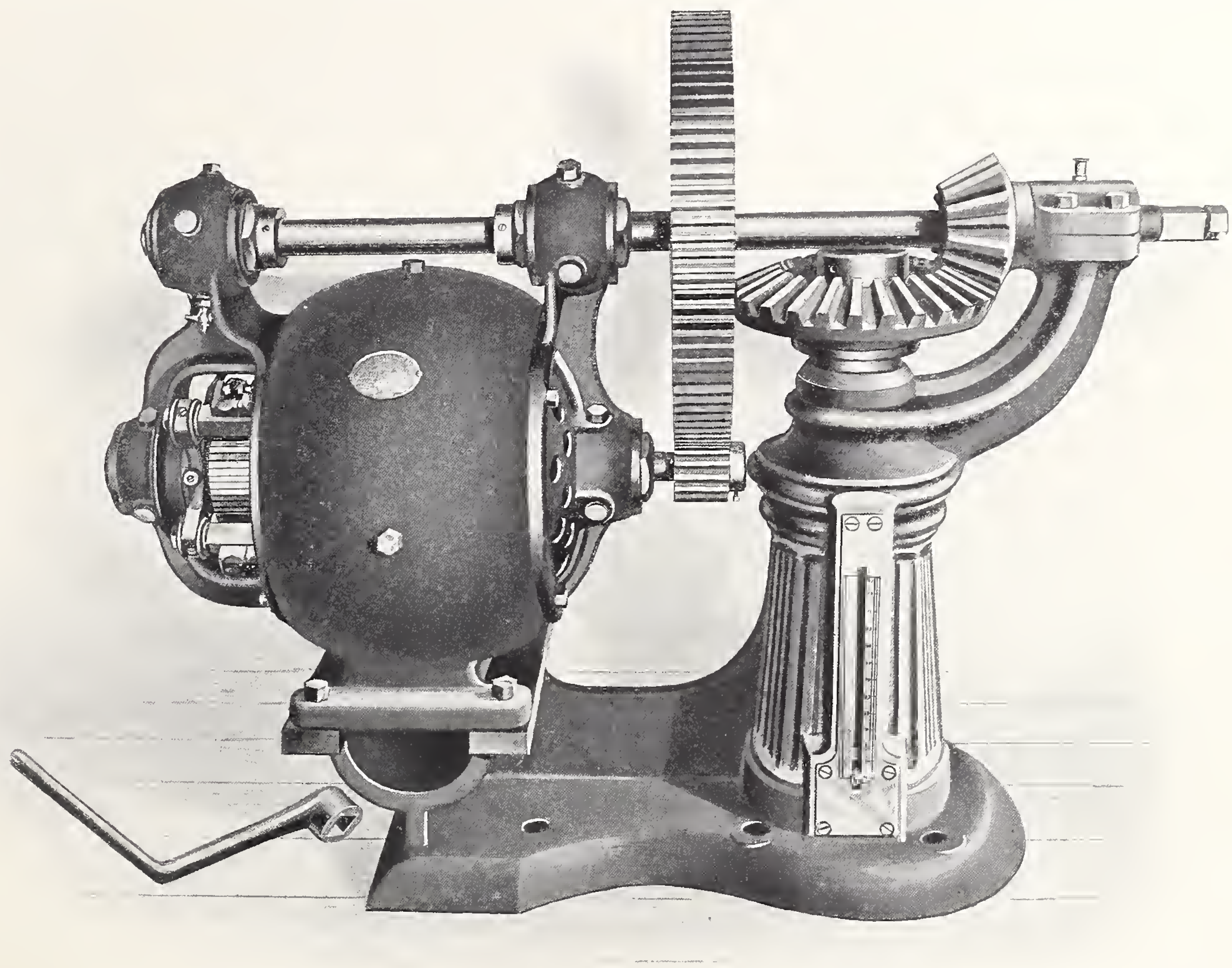


FIG. I.—MOTOR STAND FOR OPERATING A NON-RISING SCREW GATE VALVE. THE VALVE IS MANUFACTURED BY THE COFFIN VALVE COMPANY, NEPONSET, BOSTON, MASS.; THE MOTOR, BY THE NORTHERN ELECTRICAL MFG. CO., MADISON, WIS.

A motor which will give the de-

sired slow speed of about 150 revolutions, without being larger or much more expensive than a standard-speed motor, and not requiring a valve standard supplied with special conveniences, bearings and shafts for an intermediate set of gears, is obviously what is needed, and for this purpose the back-geared motor adopted in this case has been found particularly suitable. The armature shaft is geared to a countershaft, as shown in the accompanying illustrations, the countershaft having a speed of from 120 to 180 revolutions per minute, varying with the size of the motor. No special construction of the valve standard is necessary, except a simple support for the motor.

Fig. 1 illustrates a motor operating a valve with non-rising screw. The back-gear shaft is shown extending through the outer bearing. A removable crank can be mounted on this shaft, should hand operation of the valve become necessary or desirable,—for the last few turns, for example, in full opening or closing. This crank is not necessary except where certain safety devices for automatically stopping the motor are dispensed with. At the front of the standard there is an indicator which shows the position of the valve.

Fig. 2 shows a motor-operated ball-bearing standard. The motor in this case as well as in the other, is enclosed, the back gears being mounted on the outside of the motor. The rotating nut in the ball-bearing standard, which carries the weight of the valve, is secured and rests on ball-bearing races, claimed to make the operation of the valve 60 per cent. easier than when ball bearings are not used. A double set of balls below the rotating nut carries the entire weight of the shaft and valve. To take care of the thrust when the valve is closing, a single set of balls is provided above the nut.

The motor is controlled from the switchboard, conveniently located either at the motor or some central station, which may be a long distance from the motor and valve. From this board the motor may be started, stopped, reversed or automatically stopped when the valve is full open or closed. A slight movement of the lever enables the operator to place the valve in any desired position, and safety cut-outs and full-load devices prevent accidents by stopping the motor if for any reason heavy strains are thrown on any part of the valve mechanism or motor.

Fig. 3 illustrates the standard Coffin gate valve equipped with a Northern Universal motor. The gate proper is of the ordinary type, with one piece valve not easily injured by jamming plug to its seat. The motor is supported in a split bracket which is solidly bolted to the gate cap. The gearing is simple and provides proper reduction of speed for operating the bronze screw. An indicator wheel placed in close proximity to the handle shows at a glance just how far the gate is open or closed and by reversing the position of the lever the operation of the gate is stopped. Provision is made for the operation of the gate by hand when this is essential.

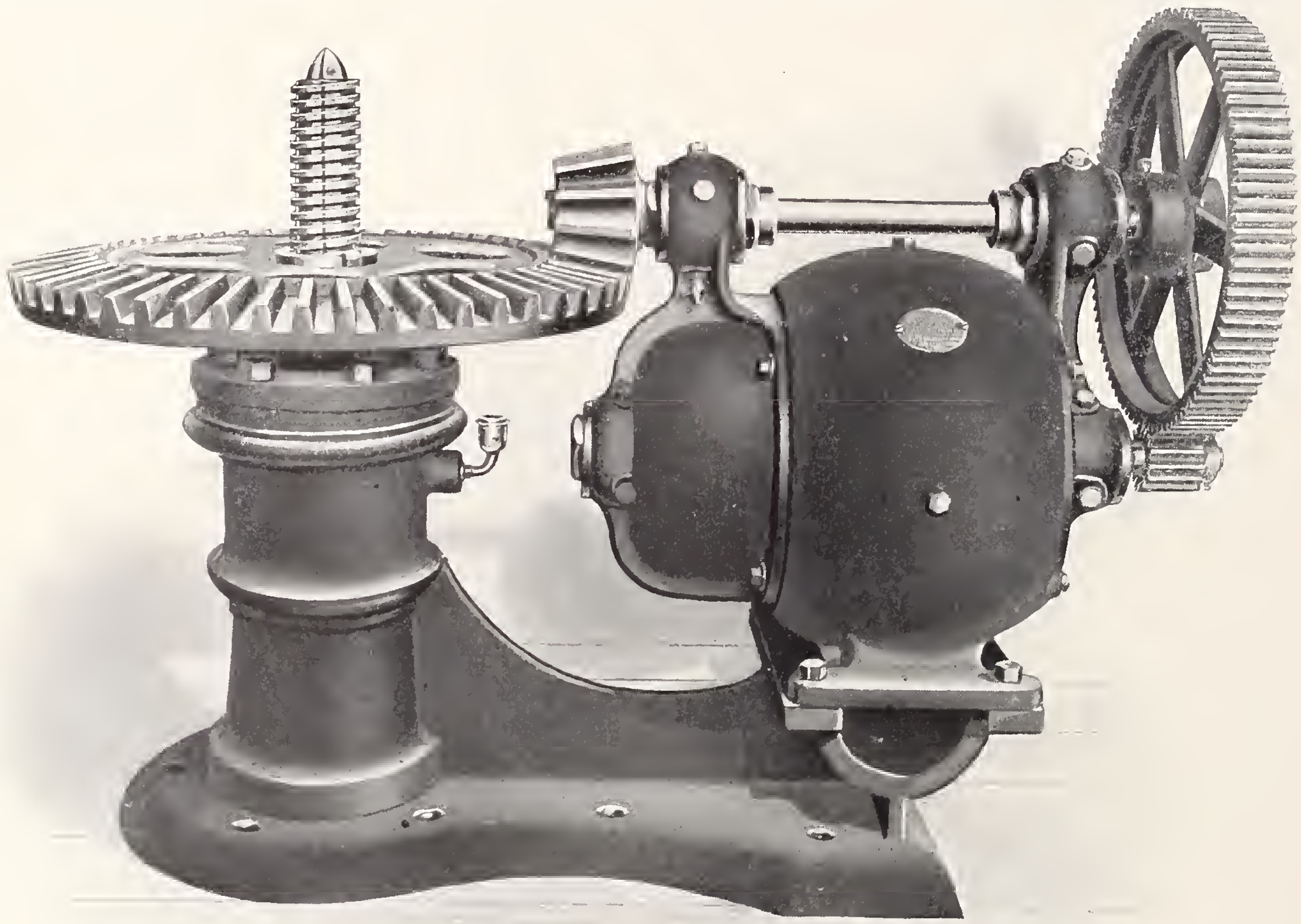


FIG. 2.—MOTOR STAND FOR OPERATING A RISING SCREW SLUICE OR GATE VALVE

If the valves are not accessible for lever-throw devices, gates can be arranged to be controlled from a common switchboard from any distance. The motor is first brought up to speed and the valve operated by throwing the clutch.

Applications of the Hewitt Mercury Vapor Lamp

TO the admirable article on the Hewitt mercury vapor lamp, by Dr. A. P. Wills, printed elsewhere in this issue, it may not be amiss to add a few particulars of its commercial applications. As Dr. Wills has told, the light of the lamp is lacking in red rays, and is thus unsuitable where accurate determination of color values is essential; but as it is the red light rays in artificial illumination that are chiefly responsible for the fatigue of the eyes, the Hewitt light would seem to particularly commend itself for many purely utilitarian purposes.

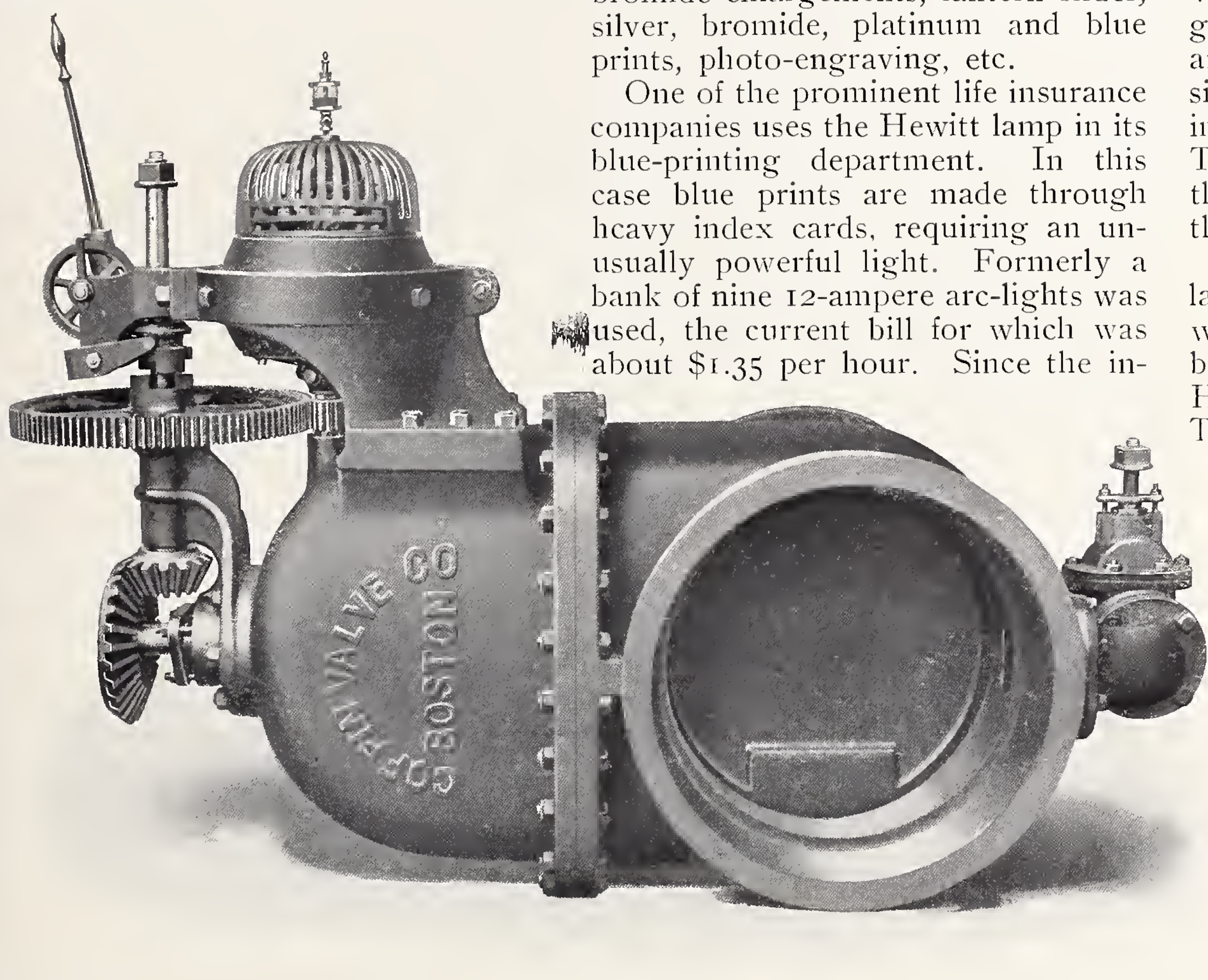


FIG. 3.—ANOTHER FORM OF MOTOR-OPERATED GATE VALVE

Another point greatly in its favor is that the light is diffused instead of concentrated, as in the ordinary incandescent-lamp unit, approximating closely to what for many years has been considered the ideal artificial illumination. It affords in practical form the "stick of light" which was enthusiastically spoken of a dozen years ago as the rational light of the future—something to be hoped for, but not then commercially attainable. For offices, factories, store houses and draughting rooms, the new light is thus particularly well suited.

Two Hewitt lamps were recently installed in the composing room of one of the New York evening papers, replacing in this case two clusters of six 16-candle power incandescent lamps. The current consumption of the incandescent lamps was altogether 660 watts, while that of the vapor lamps was only 330 watts.

Possibly the greatest field of application of the Hewitt lamp lies in photography. The light of the lamp being so diffused, and composed to a great extent of chemically active rays, it furnishes for this work, for which there has never been a thoroughly satisfactory illuminant, an excellent substitute for daylight. It is at present employed in the various branches of photography, such as portrait work, for photographing interiors, making bromide enlargements, lantern slides, silver, bromide, platinum and blue prints, photo-engraving, etc.

One of the prominent life insurance companies uses the Hewitt lamp in its blue-printing department. In this case blue prints are made through heavy index cards, requiring an unusually powerful light. Formerly a bank of nine 12-ampere arc-lights was used, the current bill for which was about $1.35 per hour. Since the installation of an equal number of Hewitt lamps the current bill has been reduced to 45 cents an hour, besides which the work is being done within half the time formerly consumed.

In a number of cases in New York City Hewitt lamps have been installed in the show-windows, the novel form and color of the light creating a most striking and effective display. In one instance two Hewitt lamps displaced sixty-six 16-candle-power incandescent lamps, and reduced the bill for current from 25 cents to 10 cents an hour.

For general lighting, it is stated that one Hewitt lamp, consuming 3 amperes or 330 watts, will give more illumination than one 6-ampere arc at 660 watts; while one 330-watt Hewitt lamp will replace nine 32-candle-power incandescent lamps, and give much more than twice the amount of light, using only one-third the current; or the same lamp will replace twelve 16-candle-power incandescent lamps, giving over three times the light for one-half the current. Where greater distribution is required, two half-length 165-watt vapor lamps may be run in series.

For photographic purposes the saving in current is claimed to be still greater. Two of the vapor lamp printing outfits, consuming from 12 to 14 amperes, will yield as many prints as an arc lamp taking over twice the current, and in less time. With two of the Hewitt photo-engraving lamps, consuming about 7 amperes, exposures can be made in six minutes where two arc lamps taking 25 amperes take eight minutes. The efficiency of the vapor lamps is therefore over 4.5 times as great as the focusing arc.

It might be added that Hewitt lamps are sold outright, complete, with all the necessary appurtenances, by the manufacturers, the Cooper-Hewitt Electric Company, 220 West Twenty-ninth street, New York.

Facilitating Telephonic Communication

WITH all the progress made in telephony, the directory or method of ascertaining the number of a subscriber has scarcely improved or developed from its original form. There have been scores of devices put on the market in the form of supplementary telephone directories, books, cards and other attachments, aiming to aid the user of the telephone in quickly locating the name and number of a subscriber, and a newcomer in this field is described below.

Mr. M. Holtz, 200 Greene street, New York City, has recently, by reason of the constant annoyance and delay incurred in looking up names and numbers in the telephone directory, invented an attachment which places at the disposal of the subscriber means of instant reference to any name and number without looking through a large, cumbersome book.

This attachment consists of a bracket which can be attached to the post of a portable telephone above the receiver hook, with a slotted bracket containing cards arranged as in a card index, permitting any classification by business, alphabet, or any way that suits the convenience of the user. A

card may be withdrawn and any number of names of the same general classification up to the capacity of the card may be seen at a glance, and the card will drop back in its place by its own weight. The projecting tabs on the top of the cards afford an instant guide to the contents and permit of ready withdrawal of any card or cards.

One great advantage of this device lies in its permanent attachment to a portable desk telephone which is being constantly shifted around from one place to another, where wall cards, index books or other separate devices lose their value by reason of not being handy when wanted. This is obviated in the case of this attachment. This invention also makes possible a great saving on the part of telephone companies. The cost of revising and publishing directories is a very large

A NEW SUPPLEMENTARY TELEPHONE DIRECTORY

item. With the general use of this attachment by a local company, the average subscriber would have little occasion to refer to the telephone directory, inasmuch as he is generally limited in the number of people he wishes to communicate with by telephone. Forty or fifty names serve the average user of the telephone, and these and many more could be very nicely handled in this attachment. Where a company publishes several editions of a directory each year, one edition would probably be sufficient, providing one of these devices was permanently attached to each telephone.

The first card is instantly visible to the user of the telephone, this card being reserved for the most frequent calls. Furthermore, its use will permit an exchange operator to repeat a wrong or changed number call, and request that it be changed on the card, thus avoiding a re-occurence of the same error. Business men who want quick service and instant means of reference will appreciate this invention, while its error-reducing possibilities should possess equal interest for mechanical and electrical superintendents of telephone companies.

Another evil which telephone companies have to contend with is the tendency on the part of subscribers to memorize numbers owing to the rapid growth in the bulk of directories. This produces errors, double calls, the tying-up of trunk lines, and is a most frequent source of annoyance to both user and operator. As this attachment is made both for portable and wall telephones, its use would doubtless tend to greatly minimize delays or errors in calls.

The simplicity and utility of this device are readily apparent. It opens up an interesting situation for local telephone companies that wish to economize in the publication of their directories, and as it in no way interferes with the mechanical or electrical parts of the telephone, it will undoubtedly be received with favor by the telephone companies whose business it is intended to facilitate.

New Electric Cooking Devices

THE high cost of electric cooking has stimulated the ingenuity of inventors, some of whom have been trying to devise special apparatus that shall be economical. The "Revue Scientifique," Paris, gives a description—translated in "The Literary Digest"— of two devices which have been invented by a Frenchman.

The first is a modification of Papin's digester. It has double walls and a double bottom. The latter contains carbon filaments to heat the vessel. That these filaments may not be burned out, the air is replaced by hydrogen, which has great convective power. This gas behaves like a perfect electric insulator that is at the same time a good conductor of heat. It transmits to the bottom of the vessel the heat energy given up to it by the filaments, almost as well as metal would do. The filaments are grouped in two series, so that the temperature in the vessel can be varied without useless expenditure of current.

The second device is for heating liquids in any vessel whatever. It is a metal cylinder with wings. In the inside is arranged a carbon resistance surrounded by an atmosphere of hydrogen. The heat given out is entirely used, since the heating is from the center outward. If the vessel that holds the liquid is itself of double-walled glass, with the intervening space exhausted of air and silvered, liquids can be boiled therein more economically than by any other method.

Automatic Continuous Feed Electric Blue-Printing Machine

A MACHINE recently placed upon the market by Messrs. Williams, Brown & Earle, 918 Chestnut street, Philadelphia, Pa., will make continuous blue prints of any length, without stop or adjustment. It will operate on any incandescent electric circuit, either 110 or 220 volt direct, or 104 alternating.

The tracing and sensitized paper are fed into the machine from the table. The instant they enter the machine, they are automatically clasped by two transparent continuous bands, which travel at exactly the same rate of speed. These bands hold the print and tracing in absolute contact, and they are thus carried in front of the electric lamps, and print as they pass. The speed at which these bands move can be adjusted so as to travel either fast or slow, enabling the operator to print with equal results through the thinnest tracing linen or the thickest tracing or bond paper. The machine is supplied with from three to five electric lamps. These lamps are suspended from an iron frame in such a way that the light from them falls directly on the tracing and sensitized paper as they pass. The print is thus automatically made, without any manipulation on the part of the operator.

The continuous bands which carry the sensitized paper and tracing in front of the lamps are actuated by an electric motor which runs on the same current as that supplied to the lamps.

The machine occupies a space five feet square. The manufacturers claim that the chief feature of the apparatus is in its extreme simplicity and in its elimination of cylindrical glass guides, pads or tension springs of any kind. Electrical printing machines are being used in large numbers, in order to get rid of rush work, and also because they are in instant readiness for service, notwithstanding the condition of the weather.

Fabrics Heated by Electricity

A CURIOUS application of electricity which has just been announced—and is described in "La Nature"—is all the more interesting because it appears to be practical as well as novel and in-

genious. The invention is that of M. Camille Herrgott, and is designed to produce moderately high temperatures in connection with carpet or other fabrics. The apparatus forms a part of materials composed of any fiber—hemp, cotton, linen, or silk, and it neither detracts from their usual appearance nor from their pliability.

The result is obtained by the use of a textile penetrated by an electro-thermic series. This warming mesh is manufactured on looms in any size appropriate for light or heavy fabrics, in the same manner that the purely textile mesh is made. All danger has, it is thought, been avoided by making it impossible for the conducting mesh to be heated above a certain point. Thus there is complete security; to such a degree, indeed, that one may wet the fabric and then dry it by turning on the electric current. The danger from an arrest of current is avoided by the arrangement of the conductors within the fabric, where they are so completely imprisoned that they cannot be brought into conjunction by the most severe manipulation.

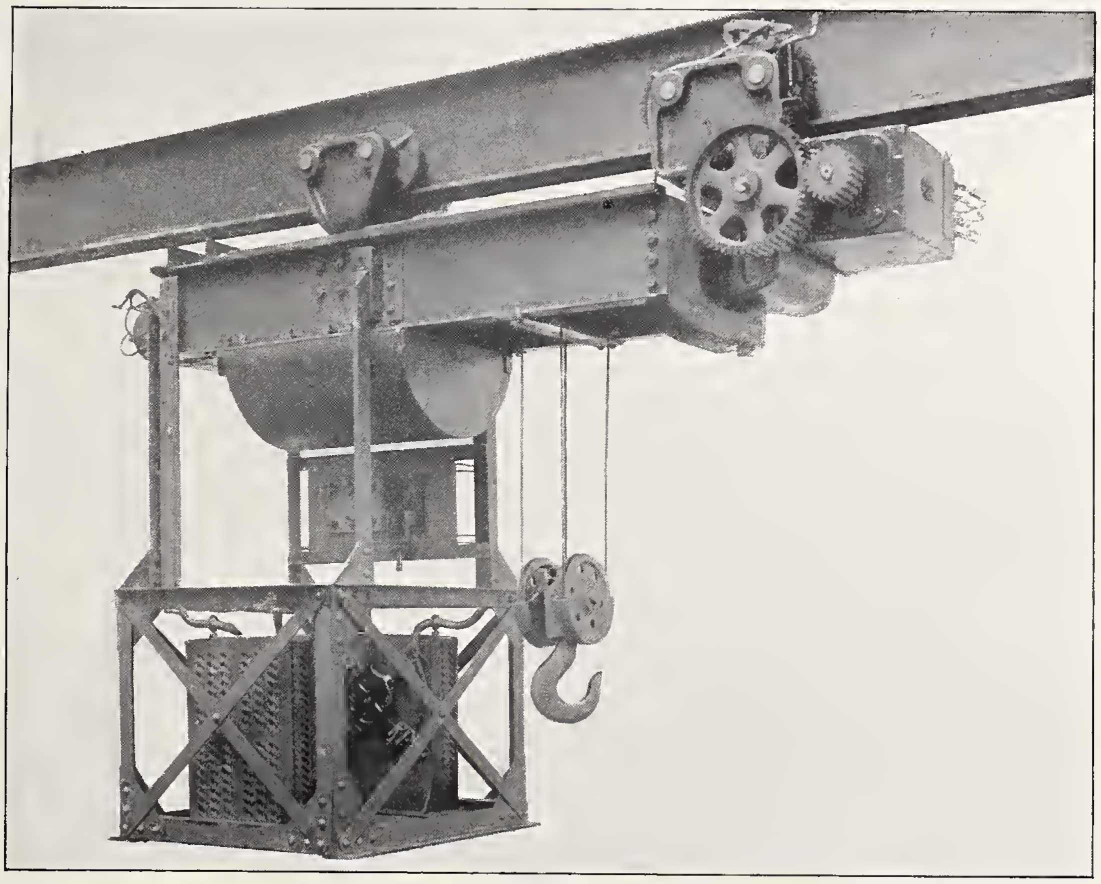
The applications of this arrangement are very numerous. Carpets, rugs, etc., may be maintained at the temperature of the body or higher. In dry or wet medical applications a temperature as high as 150 degrees C. could be maintained without difficulty. The industrial applications of the invention are innumerable, as, for example, in filters for fatty or glutinous matters, and for warming electrical carriages or railroad trains, etc.

2-10

A New Electric Traveling Hoist

THE annexed illustration of an electric traveling hoist just brought out by the Niles-Bement-Pond Company, of New York, leaves little to be told of the general makeup and use of the outfit.

These hoists may be equipped with a cage, as shown, or may be arranged to be operated from the floor by means of pendant controllers. The hoisting mechanism is placed between the channel framing of the trolley and is direct geared to the drum, a standard load and motor brake being provided. Power for hoisting, in all cases, is furnished by electric motors, while the trolley travel may be arranged for by motor or hand racking.



A NEW ELECTRIC TRAVELING HOIST, MADE BY THE NILES-BEMENT-POND COMPANY, NEW YORK.

This type of hoist is built in three sizes of three, four and ten tons capacity. Swivel trucks will be furnished for use on curved tracks.

Personal

An electric storage battery outfit is the latest modern convenience installed in the palace at Tokio of the Emperor of Japan. It was supplied by the Gould Storage Battery Company, of New York, the negotiations for putting it in having been conducted by Mr. Ph. R. Tuttle. The battery will be used to light the palace and will be charged by a generator driven by a Nash gas engine. It is the first private storage battery installation in Japan.

The non-acceptance of the Legion of Honor decoration by M. Curie seems to have encouraged more substantial recognition of his work. One of the best equipped laboratories in the Pasteur Institute has now been placed at the disposal of the savant and his wife. Moreover, a bill has been introduced in the Chamber of Deputies by M. Gerault-Richard opening a special credit of $30,000 to permit M. Curie to continue his researches. There is every prospect that the bill will be passed by a unanimous vote.

Mr. W. S. Montgomery, who has for the past five years been connected with the Conover Condenser Manufacturing Company, of Jersey City, as their secretary and sales manager, has severed his connection with that company to assume the management of the Payne Engineering Company of New York City, who are the selling agents of the Payne Company of Elmira, N, Y., builders of simple and compound automatic engines. On January 1 the Payne Engineering Company removed to new offices in the Havemeyer Building, 26 Cortlandt street, New York.

Mr. Seward Babbitt, for a number of years sales agent for the William Tod Company, of Youngstown, Ohio, has resigned his position to go with the De La Vergne Refrigerating Machinery Company, of New York City, where he will devote his time to the sale of the Koerting gas engine.

Mr. W. J. Johnston, formerly proprietor of "The Electrical World," of New York, has sold to Mr. H. M. Swetland his stock interest in the "Engineering and Mining Journal," and has severed his connection with that publication.

Mr. J. E. Woodbridge, of the railway engineering department of the General Electric Company at Schenectady, has been transferred to the British Thomson-Houston Company, at Rugby, England, where he should now be addressed. Mr. Woodbridge was at one time one of the editors of "The Electrical World" and left its staff a few years ago to devote himself more particularly to direct engineering work.

Mr. T. H. Bailey Whipple has returned to the Sawyer-Man Electric Company to the position which he left last summer in order to take a part in the reorganization of the sales department of the Nernst Lamp Company, of Pittsburg. Mr. Whipple is an old hand in the commercial end of the electric lighting field. He was general sales agent with the Buckeye Electric Company, of Cleveland, Ohio, and held a similar position with the Jandus Electric Company, which was an off-shoot of the Buckeye Elec-

tric Company, and during his connection with these two companies established most of their agencies throughout the United States. Early in 1903 Mr. Whipple went to the Sawyer-Man Electric Company, where he remained until he was called as above noted to the Nernst Lamp Company.

Mr. H. F. J. Porter, after a service of nearly ten years with the Bethlehem Steel Company, first as Western sales agent at Chicago, then as assistant sales agent at the works at South Bethlehem, and later as Eastern sales agent in New York City, severed his connection with this company on Jan. 1, 1903, to associate himself with the Westinghouse interests. After a connection of some months with Westinghouse, Church, Kerr & Co., during which time he was familiarizing himself with the interrelation of the various Westinghouse interests, Mr. Porter was appointed assistant manager of the Westinghouse Companies' publishing department, with headquarters at Pittsburg and New York City. On Dec. 1 last Mr. Porter was appointed second vice-president, with the attendant duties of general manager, of the Nernst Lamp Company, of which company Mr. George Westinghouse is president. The company's works are in Pittsburg, with sales offices in the principal cities of the United States.

H. F. J. PORTER

Mr. Max Loewenthal, secretary and electrical engineer of the Prometheus Electric Company of New York, is making a trip through the principal cities of the Eastern and middle Western States in the interests of his company for the establishment of agencies.

Mr. John D. Allan, who was recently made general manager and a vice-president of the Allis-Chalmers Company, has been connected with that company a little over 22 years, having entered the company's employ in May, 1881, as a draughtsman in the engineering department. A few years later the company established a general sales office in Chicago in charge of Mr. Allan. After the formation of the present Allis-Chalmers Company, Mr. Allan was placed in general charge of the engine sales department, which position he has held up to the present time.

JOHN D. ALLAN

Mr. Horace F. Parshall and Mr. R. W. Blackwell, of London, are making a short visit in this country.

Mr. Louis J. Magee, who for some fifteen years past has been prominently identified with electrical engineering and manufacturing in Germany, has returned to this country. He was early connected with the old Thomson-Houston Company and was one of the first representatives abroad of American electrical interests. At the present time he is a director in both the Allgemeine Elektricitæts-Gesellschaft, and the Union Elektricitæts-Gesellschaft, of Berlin, and will now be their agent in the United States. He has opened an office at 25 Broad street, New York City, and has already renewed with pleasure a great many old acquaintanceships. Mr. Magee is an acquisition to local electrical circles.

LOUIS J. MAGEE

Announcement was made recently that a new and unique school of electrical engineering would be founded during the current year by Mr. Nunn, of Telluride, Col. It is the intention of the founder to give a full course in mechanical and electrical engineering at Provo Canon, Utah, keeping the students actually employed and under pay during the period of their course.

Rear Admiral George W. Melville, ex-chief of the bureau of steam navigation, U. S. Navy, has consented to act as engineer-in-chief of the Audit & Appraisement Company of America. He has returned recently from a trip to Mexico, where he was engaged in making an inspection of some of the properties of the United Mining & Development Co. of America.

REAR ADMIRAL GEORGE W. MELVILLE, U. S. N.

Hon. Bird S. Coler, formerly comptroller of New York City, was recently elected a member of the board of directors of the Peckham Manufacturing Company, of New York, manufacturers of car trucks.

Prof. F. B. Crocker, of the electrical engineering department of Columbia University, New York City, has sailed with Dr. M. I. Pupin for a short winter trip in Mediterranean waters, proposing to be back by the end of February.

The following additions and changes have recently been made in the different staffs of the Bullock Electric Manufacturing Company, of Cincinnati, Ohio:—Halbert P. Hill will take charge of the company's exhibit at the St. Louis Exposition in 1904; W. L. Fairchild, late treasurer of the J. F. Kelly Engineering Company, has joined the forces of the Bullock Company and will operate from the New York office; A. F. Rolf, assistant to R. T. Lozier, general manager of sales, has been transferred to the New York office as assistant district manager, E. W. Goldschmidt being the dis-

trict manager; Walter B. Spellmire, district manager at Atlanta, has taken the vice-presidency of the A. W. Wychoff Company, at Pittsburg, which succeeds the Pittsburg Engineering Company as representatives of the Bullock interests in that territory; G. C. Henry, general manager of the Florida Electric Company, will succeed Mr. Spellmire as district manager at Atlanta. The various changes in the Bullock Company are made to take care of the very material increase in the demand that has been made for Bullock apparatus.

Mr. Francis B. Allen, second vice-president of the Hartford Steam Boiler Inspection & Insurance Company of Hartford, Conn., has been mentioned as a likely successor to the late President J. M. Allen, of that company. The new president will probably be named at the company's annual meeting this month. Mr. Francis B. Allen has been connected with the company since 1872, when he became the special agent of its New York department. In 1882 he was promoted to the position of supervising general agent in the home office, and moved to Hartford, Conn., and in 1888 he was made second vice-president of the company. His department includes the general supervision of the company's business in the field and the superintendency of its agents. The duties involved are most arduous, and require special skill and adaptation to the work, both of which Mr. Allen possesses in a remarkable degree. He is a member of the American Society of Mechanical Engineers, New York; a member of the American Society of Naval Engineers, Washington, D. C., and also a member of the American branch of the International Society for testing Materials, Philadelphia.

FRANCIS B. ALLEN

Dr. Clayton H. Sharp, engineer of the electrical testing laboratories of the Lamp Testing Bureau, New York City, has returned from an interesting trip to Europe, where he visited all of the principal electrical laboratories. Dr. Sharp gathered a mass of data and information which will enable him to fit up the new laboratories of the company at Eightieth street and East End avenue with the most complete and up-to-date apparatus and by the best methods known. He carried with him a number of carefully prepared standard photometer lamps, which were compared by the principal photometrists of Europe with their authorized standards, and found to be in extremely close agreement with the best of them. The Lamp Testing Bureau will probably occupy their new laboratories some time during this month.

Mr. N. S. Braden, formerly manager of the Westinghouse Electric & Manufacturing Company's district office at Cleveland, Ohio, has been appointed sales manager of the new Canadian Westinghouse Company, Ltd., and assumed the duties of that office on January 1, 1904. Mr. Braden succeeds the late Thomas C. Frenyear, who died on December 10 of last year. Mr. Frenyear's office was at Toronto, but Mr. Braden will make his headquarters at Hamilton, Ont. Mr. Braden was born at Indianapolis, Ind., thirty-four years ago. He finished his schooling in 1892, and went with the Jenny Electric Motor Company in his native city. He remained with that company until 1899, when he joined the Cleveland district sales office of the Westinghouse Electric & Manufacturing Company as a salesman, where he later became manager. Mr. Braden is known as one of the ablest and best informed electrical salesmen in America.

The British Schukert Company, Ltd., which was organized in London some years ago to handle the electrical apparatus of the Schukert Electric Company, of Nürnberg, Germany, has been absorbed by Messrs. Siemens Brothers & Co., Ltd., of London and Woolwich, of which Mr. Alexander Siemens is the managing director.

ALEXANDER SIEMENS

Messrs. Henry Hine and Leonard C. Curtis, who were recently in New York in conference with Mr. Charles A. Coffin, president of the General Electric Company, and Mr. John Hays Hammond, about some new power transmission projects of the Guanajuato Electric Light & Power Company, in which concern all are largely interested, have left for Colorado Springs, from where Mr. Hine will proceed to Mexico.

Prof. Alexander Graham Bell has returned from Genoa with the remains of James Smithson, the English founder of the Smithsonian Institution. Prof. Bell offered three years ago to bring the remains of Smithson here at his own expense, and renewed the offer last spring. The removal of the remains at this time was desirable because a stone quarry has encroached on the English cemetery at Genoa to such an extent that it became necessary to move the bodies buried there.

ALEXANDER GRAHAM BELL

Mr. P. G. Gossler, electrical engineer, etc., of the Montreal Light, Heat & Power Company, has resigned his important and responsible position there in order to become associated with the well-known engineering firm of J. G. White & Company, of New York.

Mr. W. J. Wilgus, fifth vice-president of the New York Central & Hudson River Railroad, recently returned from a short trip through England, Scotland, France, etc., investigating electric railway practice and particularly railroad terminals abroad.

Mr. Walter H. Whiteside, manager of the detail and supply department of the Westinghouse Electric & Manufacturing Company, has been appointed general manager of the Sawyer-Man Electric Company. Mr. Whiteside continues in the management of the Westinghouse detail and supply department, the business of which he has greatly increased.

Mr. William Schwanhausser, chief engineer of the International Steam Pump Company, has returned from a two months' trip to Europe, where he went for the purpose of visiting several of the large engineering works in England and on the Continent.

Mr. George Westinghouse sailed for Europe on January 26, by the North German Lloyd steamer "Kaiser Wilhelm II."

Mr. F. B. Duncan has recently been appointed manager of the Akron Electrical Manufacturing Company, of Akron, Ohio. About two years ago Mr. Duncan resigned the position of general superintendent, which he had held for about five years with the Northern Electrical Manufacturing Company, of Madison, Wis., to accept a similar position with the Akron Company, and his present promotion is an evidence of the company's appreciation of his services. During his connection with the Akron Company he has redesigned their entire line of machines and the growth of the business has been notable.


F. B. DUNCAN

Mr. Irving H. Reynolds, formerly with the Allis - Chalmers Company, and for many years identified with the design and construction of that company's engines, has accepted a position with the William Tod Company, of Youngstown, as consulting engineer.

Obituary

Hon. W. W. Skiles, president of the Shelby Electric Co., of Shelby, Ohio, died of pneumonia on January 9. Mr. Skiles was born at Stoughstown, Pa., in 1849 and graduated with his brother, George M. Skiles, at Baldwin University, Berea, Ohio, in 1876. The Skiles brothers studied law in Mansfield, Ohio, and were admitted to the bar in 1878. Immediately afterward they began the practice of law at Shelby. Mr. Skiles was married in 1877 to Miss Dora Matson, and a son and daughter were born to them. Mr. Skiles always kept up the practice of law, but was interested in many industrial enterprises He had been president of the Shelby Electric Company since its organization in 1896. Mr. J. C. Fish, secretary of the Shelby Electric Company, writes:—"Mr. Skiles was one of the original promoters of the Shelby Electric Company and was its president from the time of its inception until his death. * * * The Shelby Electric Company has lost in Mr. Skiles a splendid adviser and one who, although not actively engaged in the electrical line, had many friends among the manufacturers and large consumers of lamps." Mr. Skiles was also interested in the People's Telephone Company, of Shelby, Ohio.


W. W. SKILES.

Trade News

The Mexican Light & Power Co. is about to place a contract for about 2000 steel towers which are to be used for carrying its transmission lines from Necaxa to Mexico City and El Oro—a distance of about 150 miles in all. The Necaxa plant is to have an initial capacity of 45,000 h. p., to be ultimately increased to 80,000 h. p. The bulk of the machinery for the initial plant has already been ordered. The turbines will be of Swiss build. Escher, Wyss & Co., of Zurich, have taken the contract. Siemens & Halske, of Berlin, secured the generator contract, while the General Electric Co. will build the transformers. The Riter-Conley Manufacturing Co., of Pittsburg, will supply the steel pipe. Before the system is completed it is expected that fully $10,000,000 will be expended. The work, it is calculated, will take nearly three years to finish. F. S. Pearson, the consulting engineer of the Metropolitan Street Railway, is vice-president of the Mexican company, the New York offices of which are at No. 29 Broadway.

According to a recent communication from United States Consul S. Berliner, at Teneriffe, Canary Islands, the electric light company of Teneriffe is desirous of purchasing an American electric light engine of at least 500 horse power, as with the machinery they now have they find it impossible to meet the large and constantly increasing demand for electric light. The engine required must be of the latest pattern, of first-class material, and up to date in all respects. Price should be quoted c.i.f. Teneriffe. The following firms issue through bills of lading at Teneriffe: Elder, Dempster & Co., Produce Exchange, New York, and J. M. Ceballos & Co., Wall street, New York. Quotations and all communications should be addressed to Señor Don Nicolas Marti, presidente Compania Electrica e Industrial, Teneriffe.

The Warren Electric Company, Sandusky, Ohio, are building a 10,000-light incandescent generator for a new lighting plant at Martinsburg, W. Va. This is one of the largest generators they have ever built and will weigh over 10,000 pounds.

The Allis-Chalmers Co. announces that it has acquired the exclusive rights for the United States, Canada and Mexico for the manufacture and sale of Nurnberg gas engines for all power purposes. These engines have been developed and thoroughly tested in large units and it is claimed that their performance will meet the most exacting demands of power generation with absolute reliability. They will operate with either natural, producer, coke oven, blast furnace or illuminating gas; and they are built in sizes of from 130 to 6000 h. p. capacity. They are of the four-cycle, double-acting type. The Allis-Chalmers Co. is now prepared to install complete gas power plants.

The City Council of Warrensburg, Mo., is considering the proposition of building an electric light plant to be owned by the city.

The Rawson Electric Company, Elyria, Ohio, will begin the erection of a manufacturing plant this month.

The Schaghticoke Electric Power Company, Schaghticoke, N. Y., have engaged Chas. E. Collins, hydraulic engineer, Drexel Building, Philadelphia, to prepare plans and specifications with estimates for a power plant on the Hoosick River at that place. About 3500 horse power will be de-

veloped by water power and one 1000 horse power steam unit will also be installed.

The International Steam Pump Company, New York, have placed orders with the General Electric Company of Lynn, Mass., for direct-connected motors for pumps to go into Mexican mines. They will vary in size up to 200 horse power and will operate pumps having capacities of from 100 to 1500 gallons a minute, with long heads.

The Brooks plant of the American Locomotive Co., Dunkirk, N. Y., is completing a number of improvements, including the installation of a compound, direct-connected Brown-Corliss engine of 800 h. p. and a 500-K.W. General Electric generator. A number of new motors will be installed at once, greatly increasing the shop capacity. A new wheel shop, 120 by 225 feet, is nearing completion, the equipment including a number of electric traveling cranes, a 101-inch driving wheel and a new quartering machine. The floors are of tar concrete. All departments of the works are running full and orders for many months ahead are reported.

H. W. Johns-Manville Co., New York, is putting on the market a new insulating material for high tension electric cables for which the trademark "Niagrite" has been adopted. It is furnished in strips of several widths from 3 inches to 36 inches, suitable for wrapping spirally on electrical cables and is held in place with asbestos fireproof glue, protecting the cables from external fire, and confining internal fire. The material presents a neat and permanent finish and is not affected by atmospheric conditions. It has been adopted by the Niagara Falls Power Co., International Power Co., Buffalo Street Railroad Co., New York Edison Co., and other important electrical plants.

In the new power station of the Denver Tramway Power Company of Denver, Col., mechanical draft is used as an auxiliary to the natural draft provided by a chimney 240 feet high. Artificial draft is furnished by three Sturtevant electrically driven steel plate fans. The boiler capacity of the plant is approximately 6000 horse power.

The Central Electric Company, Chicago, reports an exceedingly good business in Columbia incandescent lamps, for which it is sales agent. Up to this time Columbia lamps have only been manufactured in the ordinary incandescent and series burning types. The Central Electric Company is authority for the statement that it will now be able to supply miniature lamps of the Columbia brand which will doubtless meet with a large demand.

M. Gradstone & Co., manufacturers' export agents, 2-4 Stone street, New York City, represent American manufacturers in Russia. They are represented in all the larger cities of Russia and have had an extensive experience in selling to the various trades. Russia, with its 141,000,000 population and area nearly three times that of the United States, offers an inviting market for American manufacturers. The industries of that country are as yet in their infancy, and the 20 per cent. reduction in import duties on all direct shipments to Russian ports of entry offers opportunities for favorable competition. Gradstone & Co. would be pleased to have manufacturers submit to them catalogues from which to select articles suitable for the Russian trade.

A franchise has been granted at Beaman, Iowa, to the Marshalltown Electric & Interurban Railway Company.

The Alberger Condenser Company, 95 Liberty street, New York, were recently awarded contracts by the Manila Construction Company, P. I., for three separate high-vacuum surface condensing systems. The Manila Construction Company, who have their headquarters with Messrs. J. G. White & Company, at 43-49 Exchange Place, New York, are purchasing the equipment for the Manila Electric Railroad & Light Company, who are building a large station at Manila.

Mr. E. Stuetz, 54 Front street, New York City, who represents the thermite process controlled by the chemical and tin smelting works of Th. Goldschmidt, of Essen-Ruhr, Germany, is now in a position to supply thermite and appliances from stock in New York. Various pamphlets which can be obtained on application to Mr. Stuetz give instructions for the use of the material in a concise and clear form, so that any intelligent mechanic can be made acquainted with the thermite welding process in its various branches at a slight outlay. The great interest aroused by Dr. Goldschmidt's lecture at the annual meeting of the American Society of Mechanical Engineers has made it necessary to supply consumers' needs by importing until it will be possible to start manufacturing in this country.

The general sales office of the Christensen air brake department of the National Electric Co. has been transferred from No. 135 Broadway, New York, to the works at Milwaukee, and will hereafter be under the direct charge of Mr. F. C. Randall, who has been elected vice-president and general manager of the company. The company will retain a sales office at No. 135 Broadway, New York, which will take care of New York City and all of New England and Canada. This office will be in charge of Mr. J. T. Cunningham, who has been the New England representative of the company for the past two years. Mr. J. D. Maguire has been appointed special sales representative of the air brake department, and will make his headquarters at the New York office also, Mr. J. H. Denton, who formerly made his headquarters at the general sales office at New York, has been appointed chief of the inspection department at the Milwaukeee works, in addition to his position as chief engineer of sales department for Christensen air brakes. Mr. Denton in future will be located in the Milwaukee office.

The Laidlaw-Dunn-Gordon Company, of Cincinnati, Ohio, have begun the installation of a $30,000 gas pumping station for the Heat, Light & Power Gas Company, of Muncie, Ind.

The Sidney Gas & Electric Light Company, Sidney, Ohio, are planning to install two new engines, an incandescent light generator and make other improvements.

The Consolidated Railway, Electric Lighting & Equipment Company has elected Colonel John T. Dickinson, hitherto general agent, second vice-president. Mr. Dickinson will introduce the Consolidated "axle light" system of electric car lighting to railroads. The company's general office is now in the Hanover Bank Building, Pine and Nassau streets, New York City.

The North Shore Electric Company, which largely supplies the lighting and power facilities of the North Shore, between Evanston and Waukegan, Ill., has received a franchise from Wilmette and will soon be operating there. The growth of the company, of which Samuel Insull is president, has been highly satisfactory during the last year.

The annual meeting of the stockholders of the Standard Underground Cable Company was held at the general offices of the company in the Westinghouse Building, Pittsburg, Pa., on January 26, 1904. The statement of the company's operations for the year was presented, showing that

the company did a gross business of nearly $9,000,000 during the year 1903; that dividends were paid on its capital stock, aggregating 12 per cent., and that the company's assets aggregate the sum of $3,604,457, with only $375,344 of liabilities apart from capital stock. There are no outstanding notes, mortgages, bonds, or preferred stock. The board of directors elected for the ensuing year is made up as follows:—Mark W. Watson, John B. Jackson, James H. Willock, Robert Pitcairn, J. N. Davidson, John Moorhead, B. F. Jones, Jr., Joseph W. Marsh and W. A. Conner. The only change in the board is represented by the election of W. A. Conner, who has been at the head of the manufacturing department of the company since 1884. The meeting of the board of directors for purpose of organization was held on the 29th inst., and the former officers were re-elected as follows:—Mark W. Watson, president; Joseph W. Marsh, vice-president and general manager; Frank A. Rinehart, treasurer, and C. M. Hagen, auditor.

It is understood that the Fall River Electric Light Company, Fall River, Mass., are considering making important improvements to their power station the coming season.

The Moline Incandescent Lamp Company has been incorporated at Moline, Ill., by Albert H. Kreitler, C. F. Gantz and E. E. Morgan. The purpose of the company is to manufacture incandescent lamps and other electrical apparatus. The capital stock is $30,000, and the first board of directors is composed of the following-named gentlemen:—C. H. Deere, E. E. Morgan, W. H. Cooper, C. P. Skinner, C. R. Wood, Edward Coryn and A. H. Kreitler.

The Beardsworth Engineering & Machinery Company, Cleveland, Ohio, recently formed, will make a specialty of selling and reinstalling complete second-hand power plants. It has a number of complete plants for sale in various parts of the country. Parties having steam and electrical equipment too small for their present requirements may be enabled to make advantageous exchanges through this company.

D. M. Stewart and Charles Darlington, Xenia, Ohio, have organized a lighting company and are securing estimates on the cost of equipment for a plant large enough to illuminate the town and furnish current for private lighting and manufacturing purposes.

The stockholders of The Otto Gas Engine Works, of Philadelphia, have decided to increase the capital of the corporation from $600,000 to $2,500,000, and build a large, new plant just as soon as the management can find a suitable site for the purpose. Large gas engines, producer gas plants, launches and marine engine, gasoline hoists, compressors, and other adaptations of the gas engine will be built at the new plant. A suitable site must contain not less than 30 acres, must be located on a good water front and must have good railroad facilities.

The Dean Electric Company, Elyria, Ohio, have organized with a capital stock of $300,000 to manufacture telephone switchboards and electrical apparatus. The company are building a modern factory, and report being in the market for power apparatus and machinery equipment. Officers of the new corporation are:—President, S. B. Rawson; vice-president, W. W. Dean; secretary, A. E. Barker, and treasurer, T. M. Brush.

An important export order was closed a few weeks ago with the Manila Construction Company, an American corporation conducting operations in the city of Manila, P. I., for a complete power equipment for the city traction system. The order was secured through Westinghouse, Church, Kerr & Company, and comprises the following machinery:—Three 750-K.W. Westinghouse turbo-generator units; two compound engine exciter units; one motor-driven exciter unit; three 500-K.W. rotary converters; one 300-K.W. rotary converter; four 250-K.W. oil-insulated transformers; a complete switchboard, and one series booster. This booster is mounted on the extended shaft of one of the rotary converters. The first turbo-generator unit will be delivered in about nine months. The turbine will operate at 150 lbs. steam, 26″ to 27″ vacuum, and 150 degs. superheat. It will be fitted with the usual by-pass for securing an overload capacity of 50 per cent. It will also be equipped with a quick-closing throttle valve. The turbo-generators will furnish three-phase, 60-cycle current at 380 volts; part of the current will be converted to direct-current by the power house railway sub-station, and the remainder will go to transformers for supplying high-tension distributing system. The transformers are oil-cooled and connected in the two-phase-three-phase, or Scott system for three-phase transmission. The turbine machinery will also furnish current to the local light and power system.

The Willard Storage Battery Company, Cleveland, Ohio, manufacturers of storage batteries, have moved into larger quarters at Twenty-seventh and Clair streets, and will make extensive improvements to the building. They will install 200 horse power of boilers and engines and two 75-K.W. generators for lighting and power. They will buy considerable new machine tool equipment and will install a complete woodworking outfit for manufacturing their own battery cases. T. A. Willard is the general manager of the company.

A report from London states that a company has been formed in Berlin, under the title of the United Steam Turbine Company, to acquire the patent rights in Germany of the Curtis, the Riedler, and the Stumpff turbines. This is said to be the outcome of agreements between the Allgemeine Electricitäts-Gesellschaft, of Berlin, and the European branch companies of the General Electric Company of America, the Curtis Turbine Company, Profs. Riedler and Stumpff, and the German Inventions Introduction Company.

The Sao Paulo Tramway, Light & Power Co., operating a large power and lighting system in Sao Paulo, Brazil, is said to be preparing to extend its plant to the Tiete river. The equipment is of American build, the generators being of General Electric manufacture, while the Stilwell-Bierce & Smith-Vaile Co., of Dayton, Ohio, secured the contract for the turbines. William Mackenzie, of Toronto, is president of the company, and F. S. Pearson, of New York, is consulting engineer.

The electric railroads of the United States carried three times the population of the earth last year. The Manhattan Elevated Railway, of New York City, alone, carries over a million passengers a day.

John Leonard Kebler, of Lawrence Park, Bronxville, N. Y., died suddenly on February 2, 1904, at Albuquerque, New Mexico, from an acute intestinal disorder. Mr. Kebler's death comes as a great blow to his relatives here, as he was expected to return home in perfectly restored health within the next few weeks. Mr. Kebler was twenty-four years old. His parents died when he was eight years old; since then he has lived with his uncle, Mr. H. Ward Leonard. He graduated in 1900 from Columbia University, taking the degree of Electrical Engineer. At the age of twenty-one he was appointed Vice-President and General Manager of the Ward Leonard Electric Company, which position he held at the time of his death.

From the World's Technical Press

Electric Power in British Coal Mines

ELECTRICALLY driven coal-cutting machines are coming largely into use in Lancashire. According to the London "Electrical Review," they have been extensively employed since 1899 by one of the most prosperous colliery concerns in that county,— the Hutton Colliery Co., Ltd., whose mines are in the Wigan district,—and have been found to effectually supersede manual labor. The experimental stage has been passed.

"It may be thought," said Mr. Alfred Tonge, who is intimately connected with the management, recently, "that we have carried experimentation too far, but I do not find that we have suffered much from this. Each make of cutter we have tried has some special feature which suits the mine. The Jeffrey disc long-wall cutter was our first choice, because it seemed best to us, at the time, for thin seams. It was put to work in a half-yard seam, and afterwards transferred to a 1 ft. 8 in. seam, and its work was so satisfactory that a second machine of the same type was purchased. The next kind of machine tried was the Diamond long-wall, which was used in a thicker seam, and after that the Morgan-Gardner, which latter was obtained chiefly for the purpose of enabling us to dispense with the use of rails in thin seams, and because of its compactness. Then we experimented with the Hurd three-face bar cutter and the Diamond three-face disc cutter, in our newly opened pits." The general results of these experiments, Mr. Tonge said, was very satisfactory. The Jeffrey, the Diamond, and the Morgan-Gardner have been in use now four years, and have proved their superiority to manual labor in many ways. "The amount of coal cut by these machines," says Mr. Tonge, "in 1902, was 41,850 tons, or more than half the total amount cut by machinery in that year in the whole of the Manchester district. At the present time they are cutting at the rate of 100,000 tons for the year." Not the least important factor in the use of these mechanical cutters is a change in the character of the coal. Less slack is produced in proportion to "round coal." In the Hutton Collieries the production of coal has been increased about 10 per cent.

Mr. Tonge claims for the electrical coal cutters the following distinct advantages:—(1) More output per man employed; (2) coal economically worked which previously had been unworkable at a profit by hand; (3) more systematic working; (4) better round coal in three out of four mines; (5) greater area exposed in the same time, in two out of four seams; and (6) premium per ton for risk of life reduced by one-third.

Progress in the Generation and Use of Electric Energy

THE production of electricity direct from coal without intermediary processes, says "Cassier's Magazine," has been the dream of inventors for many years past; but energy and ingenuity in this field seem to have been largely misspent. Certainly no progress worth mentioning has been made in the past ten or twelve years, even though periodically rose-colored accounts have appeared of some new way of attaining the desired end. What progress there has been in the generation and use of electric energy has come along conventional lines—through improvement in the steam engine, the development of the steam turbine and the gas engine, and the perfecting of electric lamps and introduction of new and more economical lighting systems, such as that, for example, represented by the Cooper Hewitt mercury vapor lamp. The gas engine to-day comes nearer the commercial successful direct producer of electricity from fuel than anything else, and no one has been quicker to realize this and to try to provide for the requirements which will ultimately spring from this fact than the builder of large steam engines. Hence we find the large gas engine in a number of cases as an auxiliary output of the steam engine shop, with fair promise of becoming the chief end of the business in the near future; and where the gas engine has not thus been taken up, the steam turbine has taken its place, with the result that this once despised rotary motor is now on the market in a number of different designs and has orders to its credit of hundreds of thousands of horse power.

Electric Motor Breakdowns

JUDGED from some of the things told in the latest annual report of Mr. Michael Longridge, chief engineer of the Engine and Boiler Insurance Co., of Manchester, Eng., the insurance of electric motors would seem to be a highly speculative business. Taking a general average, one dynamo in twelve has an accident during the year, whilst one motor in eight may be expected to break down. In certain industries, however, the "mortality," if one may use the term, is much higher, since, on the average of motors employed in collieries, one in three breaks down annually; whilst of those used in actual coal cutting, the casualty rate is as high as 50 per cent. Further, this class of machine suffers from general deterioration to a marked degree.

In the case of motors, fully one-fourth the failures arise from old age The insulation in many instances is found affected to such an extent that if disturbed, it falls to pieces, and damage to a single conductor, therefore, involves the complete rewinding of the armature. Overloading, as a cause of failure, is apparently less common, but is still responsible for

one-seventh of the total motor breakdowns. In one case a two horse power motor, designed for a current of 17 amperes, was fitted with a "fuse" consisting of a length of No. 18 B. W. G. copper wire calculated to melt at 108 amperes. On test, it was found that the working current varied between 23 and 27 amperes, rising to 30 at starting. In a sister motor of the same size, the current at starting rose to 105 amperes. A curious accident noted is the fracture of the armature shaft of a small motor. The break started in a V-groove less than 1/16-inch deep, turned in the shaft to prevent the creeping of oil. The localization of strain thus occasioned is an obvious source of weakness.

Electric Car Lighting

THE Chicago, Milwaukee & St. Paul Railway has 283 cars equipped with electric light apparatus, says the "Railway Age," the current coming from a dynamo located in the baggage car and operated by a small engine, a method which has been the favorite upon that road from the earliest experiments with electric current for lighting purposes, which it began over 16 years ago. The above number of cars includes 146 coaches, 60 sleepers, 23 mail, 12 dining, 19 baggage, 18 parlor and 5 buffet cars. Nine trains thus equipped are in service each night, each train consisting on an average of 10 cars. Besides this equipment the road has 8 coaches and 9 sleepers lighted entirely by storage batteries. The electrical department is now experimenting with axle-lighting dev ces, 3 cars having been equipped with one each of three different systems.

Coal Production in 1903

REPORTS received by "The Black Diamond" show that the total production of coal in the United States was, in round numbers, 358,000,000 long tons of anthracite and short tons of bituminous coal during the year 1903. In 1902 the anthracite regions shipped 31,213,911 tons, and in 1901 the shipments aggregated 53,568,601 tons. The past year has been by far the most important in the matter of production in the history of that branch of the industry. All previous records, including that of 1901, which was considered remarkable at the time, have been broken, and it may be a good many years before production will exceed that of the year 1903.

The total production of anthracite coal for the past five years is given as follows:—

Year.	Production, Long Tons.
1899	53,944,647
1900	51,221,353
1901	60,194,530
1902	36,865,710
1903	65,500,000

The total production of bituminous coal in the United States during 1903 was approximately 292,238,505 tons, as compared with 260,033,071 tons the previous year.

The Bucholtz Steam Turbine

OF the Bucholtz steam turbine,—a new type, of German origin,—E. Kilburn Scott says, in the London "Electrical Review," that for simplicity of construction it is probably unequalled. According to his description, it consists simply of a series of brass discs or washers, half of them fastened to the case of the turbine and the other half placed alternately and mounted on the spindle, the clearance between the plates being a fraction of a millimeter. In the fixed plates a series of concentric holes are drilled straight through, that is to say, with the drill at right angles to the plate. In the rotating plates there is a similar series of holes, but they are drilled at a considerable angle with the plane of the plate. Thus, in passing through the holes from one end of the turbine to the other, the steam is thrown against the slanting holes in those plates mounted on the spindle, making them rotate.

When the steam has passed through the rows of holes nearest the periphery, it works back again through another series of holes nearer the spindle, and so on, forwards and backwards, until it finishes up at the row next the spindle. There is, therefore, no end thrust, and, by reversing the direction of the steam and putting it in at the row next the spindle and taking it out at the row nearest the periphery, the turbine is made reversible.

Gas Power for Electric Central Stations

IN a paper dealing with the advantages of operating electric central stations in connection with gas works, recently read before the American Institute of Electrical Engineers, Mr. J. R. Bibbins gives the results obtained at a large number of stations using various qualities of gas, both for steam raising and engine driving, and showing the economy resulting from the direct combustion of power gas in internal combustion engines.

The four contentions upon which he offers his testimony are:—

1. That present gas-power machinery is suitable for central station service.

2. That a well-equipped gas-power electric plant can operate with far better economy than a steam plant under similar conditions.

3. That its operation is much simpler and requires less running expense for the same results.

4. That a gasworks, laboring under low load or output factor, can profitably install a gas-power electric generating station and become its own largest customer, selling both gas and electricity at competitive prices.

From the results of the working of 12 plants having an average of about 315 B. H. P. capacity, employed for lighting and power purposes, he shows that all classes of generators are capable of being satisfactorily run by gas engines, including polyphase generators running in parallel, and demonstrates the economy obtained by replacing steam engines by gas engines.

In regard to continuous running, he instances a 65-H. P. two-cylinder vertical gas engine running for 8230 hours out of 8472, and of the 3 per cent. time in which the engine was not in operation, only 0.6 per cent. of the total time was attributable to the machine.

The engine ran for 1157 hours without stopping, and was then shut down to repair a belt. Other engines operate 96 to 98 per cent. of elapsed time. In central station works there is usually ample time for any inspection and repair. No special skill is required for operating a gas plant.

In cost, the gas engine equipment is quite comparable with that of a steam plant; especially is this the case when condensers, heaters, pumps, etc., are considered.

In economy of fuel the gas engine admittedly has no rival, the steam engine and boiler giving about 16 per cent. thermal efficiency, while the gas engine at full load gives 25 per cent. and over. An important source of economy in gas plants is the fact that as soon as an engine is shut down all heat losses cease, and that there is no such loss as condensation in transmission of the gas from the producer. Gas engines can be started up, from cold, in from 40 seconds to a couple of minutes. As between 25 per cent. and 50 per cent. of the heat employed in the gas engine is carried off in the circulating water, where this can be employed for heating purposes, the efficiency of the gas engine is greatly increased above that given.

Many classes of fuel gas are available for employment in gas engines, and when reduced to thermal value

per cubic foot of explosive mixture, the ratings are nearly equal:—

	Approximate B.Th.U. per cb. ft. Gas.	Mixture.
1. Natural gas	1,000	91.0
2. Coal gas	650	91.7
3. Water gas	300	88.0
4. Carburetted water gas	600	92.0
5. Producer gas	120 to 145	60 to 68
6. Coke oven gas	600	90.0
7. Blast furnace gas	90	53.0

Blast furnace and producer gas will give within 16 to 20 per cent. of the power in the same engine that can be obtained from coal gas, but the lower quality of gas has the advantage of less tendency to pre-ignition, or "back firing," so that compression can be carried higher, with its increased economy. A comparison between two plants gave the cost of coal in the steam plant at 1.38 cents per K.W.-hour, and in the gas plant 0.75 cents, or a saving of 45.5 per cent.

In the case of a plant first started on steam raised by natural gas, then converted to gas engines for driving, the saving in total operating cost amounted to 40.5 per cent., while though there was an increase of 30 per cent. in station output, the consumption of gas was reduced by 7 per cent.

Testing Pneumatic Tires Electrically

If pneumatic tires are tested on a revolving drum, which is the usual method employed, the curvature of the drum reverses the curvature of the fabric every time the wheel revolves, making the conditions unlike those encountered in actual service.

In order that the fabric of the tire may be merely flattened at the tread where it is distorted under load, the Palmar Tyre, Ltd., employs an apparatus in its Birmingham, England, experimental department which, the London "Electrical Review" says, is different from anything of the kind in existence. Two pneumatic tired wheels are run together, both inflated to the same pressure. By this means each tire forms the equivalent to a flat road to the other.

Wheel No. 1 is pressed against wheel No. 2 by a lever carrying heavy weights, which are in a pit underneath the apparatus. These weights represent the load. Wheel No. 2 is so arranged that it may be turned upon a horizontal line at right angles to its axle in such a manner that when so turned it revolves in a different plane from wheel No. 1. In order to keep No. 2 wheel steady, its support is attached to a heavy pendulum weighing upwards of 2 tons.

If this pendulum is caused to rock to and fro while the wheels are revolving, the strains which are set up in the fabric of the tires are similar in character to those which take place in the fabric of motor-car tires when driven rapidly round curves varying in direction.

Two 50-H. P. electric motors are employed, both of which may be used either as a motor or as a dynamo. Assuming that No. 1 wheel is driven by No. 1 motor, and that No. 2 motor is disconnected, the apparatus is then "running light," and if the pendulum is stationary in a vertical position, the conditions are then similar to those of tires on a loaded car running on a level road, No. 1 being the driving and No. 2 the front wheel.

If No. 2 motor is connected as a dynamo, then the conditions at No. 1 wheel are similar to a loaded car going up a very steep hill, and the conditions at No. 2 wheel are like those of a loaded car going down a very steep hill with the brakes fully on.

The switchboard instruments show at a glance how much electrical horse power is supplied to motor No. 1, and also how much is given out by motor No. 2 being run as a dynamo; and by making allowance for friction of the apparatus, an approximate estimate may be obtained of the power absorbed by the tires, which is very useful in comparing different makes. A series of jets of air directed on to the surface of the tires make the conditions similar to those of a motor car traveling in the open air.

The number of tests which may be made by this apparatus is almost unlimited.

By switching the electric current from No. 1 motor to No. 2, the whole of the conditions may be reversed, so that the operator can test both tires for a given time under all conditions. The strains which the fabric of the tire may be subjected to by this apparatus are incomparably greater than could possibly be given to the tires under road tests, and this is done without risk to life or limb. If a tire is not torn off its rim when running at high speed on this apparatus with the pendulum moving, it may be safely assumed that it will never come off its rim in ordinary use.

Dispersion of Fog by Electricity

In a paper before the British Physical Society, Sir Oliver Lodge describes an experiment made by him in which two pieces of wire gauze, connected to the terminals of an electric machine, were placed opposite each other in a chamber through which a current of smoke was slowly passing. Upon electrifying the pieces of wire gauze the smoke ceased passing, the dust particles cohered, hovered in the air and were either driven to the sides of the chamber or fell to the bottom. In the case of mist, the electrification of steam in a bell jar converted it into fine rain. It seems, therefore, possible that rain might be produced by the electrification of a cloud.

He tried later at Liverpool to disperse fogs by discharging electricity into them. For this purpose a large mast was erected on the roof of a convenient building, terminating in a bundle of points, to which electricity was conveyed from a Wimshurst machine by a wire supported by specially constructed insulators. The discharge points may be supplemented by a gas flame. Upon one occasion the discharge of electricity from the flame was sufficient to keep a clear space of 50 or 60 yards radius in the dense fog.

He suggests that this means may be utilized on a large scale to mitigate disastrous river fogs. He had proposed to erect for this purpose a series of masts for positive discharges on one side of a river and a series for negative discharges on the other side.

Electric Power in India

The enterprise of the Mysore Government in putting down the large hydro-electric power plant at the Cauvery Falls, in India, appears to have been thoroughly successful. The plant was designed for supplying power to the Kolar goldfields, 100 miles away. According to "The Electrical Engineer," of London, the demand for electric power at the goldfields has greatly increased since the initiation of the scheme, and the generating plant is to be extended to nearly twice its present capacity. The power house at the base of the hill is to be extended down stream to allow for the installation of five additional generating sets of 720 KW, which will be duplicates of the six now in operation. A new forebay is under construction down stream from the present forebay, and below the existing step-up transformer station. Five additional pipe lines are to be laid from the new forebay, so that each generating unit will be directly supplied, instead of one pipe line to each pair, as at present. The transformer station also is to be extended, and in order to lessen the line losses consequent on the necessary output, the transmission voltage is to be raised to 35,000 volts. The new electrical machinery is being supplied, as was that originally installed by the General Electric Company, of Schenectady, New York, U. S. A., and the new turbines, too, come, as before,

from the works of Messrs. Escher, Wyss & Co., of Zürich, Switzerland. The cost of the initial installation of about 4500 H. P. is said by "Indian Engineering" to have represented a total capital outlay of £359,817; but deducting the cost of the first year's working and the cost of the compressor houses on the goldfields, which latter is chargeable to the mining companies, the actual capital cost stands at £327,697. The actual power of the initial installation is 500 H. P. greater than was at first contemplated, and the cost per horse power as originally computed and as now installed works out as £71.84 and £72.82, respectively. The courageous policy of the Mysore Government in entering on this important undertaking receives striking approval from the way the electric power has been taken up by the mining companies, which has necessitated the large expansion of plant indicated above. And it is possible that the city of Bangalore will soon take a supply of energy for lighting purposes, as the transmission line runs within about eighteen miles of the town.

Electric Iron Smelting

WRITING on the subject of electric iron smelting, in the "Oesterreichische Zeitschrift für Elektrotechnik," Mr. A. Keller makes the point that while in most countries where the iron industry now flourishes, the electric iron furnace would not be commercially practicable, it has some promise of success in such countries where coal is scarce and water power is abundant. On this basis Mr. Keller has worked out a scheme for the erection of an electric steel plant in Brazil.

A Winter Use for Electric Fans

ELECTRIC fans of the warm-weather order have other uses, says "Cassier's Magazine," than the familiar one of stirring up the air in times of summer heat, and thus affording relief to perspiring humanity.

For preventing the frosting of display windows of shops in winter time there is nothing simpler or more effective than the air blast of such a fan directed against the glass. The philosophy of the thing is plain. The evaporative effect of the air current simply prevents condensation of moisture upon the window, and affords relief from an annoyance which generally is sought, but only imperfectly attained, through various other awkward means. Fan makers might find it worth while to exploit this field of usefulness for their wares, which, with the end of the heated term, are generally considered as cumbersome stock to be carried over to the next summer.

The Widening Use of Steam Turbines

WHILE in the United States one company of steam turbine builders not long ago had on its books orders calling for over 300,000 horse power in this type of engine, British engineers also are using it in increasing numbers.

A recent summary of what is being done in London in steam turbine installation showed, among the more important work, that the Chelsea power station of the Underground Electric Railway Company,—now building,—will be supplied with eight turbines of 7500 horse power each, or 60,000 horse power in all. For the generating station of the Metropolitan Railway Company, turbines of an aggregate of 14,000 horse power are being installed, while Brighton Corporation and Liverpool Corporation have on order plant of this type to the extent of 7500 horse power and 4000 horse power, respectively. The North Metropolitan Power Company are building a station at Brimstown which will supply energy for driving a great system of tramways in Middlesex and Hertfordshire, and there three turbines, aggregating 4000 horse power, will be used. The first steam-turbine electric plant of any magnitude in Scotland is now about to be installed for the Clyde Valley Electric Power Company, the total being 16,000 horse power. Harrowgate town council are putting down a 1000 horse power turbine, and the Yorkshire Electric Power Company have on order plant of a similar type with an output of 6000 horse power. The power is given in round numbers, but approximately the total just enumerated, neglecting the smaller installations, is no less than 112,000 horse power. The bulk of these machines are of the Parsons type, built by the British Westinghouse Company; but some are Curtis turbines, made by the British Thomson-Houston Company, and a few of the Parsons model are coming from the shops of the Brush Electrical Company. On the Continent of Europe turbine sentiment, too, is found strongly developed, and French and German and Swiss builders are all helping to swell the horse-power figures to a most commanding total.

Removing Ice from Third-Rail Conductors

A NEW method of cleaning third rails of ice and sleet, mentioned by the "Western Electrician," is to pour a solution of chloride of calcium along the rail, which will remove the ice almost instantaneously, it is said. This treatment is also said to prevent ice from collecting for three or four hours after each application. Experiments have been made on the Grand Rapids, Grand Haven & Muskegon Railway Company's lines. Three cars were used, each with reservoirs located in the motorman's vestibule. A stopcock regulated the flow of the liquid, which worked effectively with one-eighth of an inch of ice on the rail. A solution of salt has been tried for the same purpose, but has been found unsatisfactory, since it reduces the insulation of the rail.

An Alternating-Current Railway System

By WALTER M. McFARLAND

THE alternating-current single-phase railway motor, developed by the Westinghouse Electric & Manufacturing Company, makes possible a new system of electric traction, which possesses many points of advantage over that now in general use.* The superiority of the alternating current as a system of transmission and distribution has been fully established. Its application in railway service has, however, until recently, been limited to the transmission of current from a central power station to distributing sub-stations, in which it is transformed from alternating to direct by means of the rotary converter. This limitation has been due to the fact that no alternating current motor has been available which possessed proper characteristics for the operation of a car under the usual conditions of urban service.

It is essential that a railway motor for general service shall be capable of operating at variable speeds, and that this speed variation shall be under almost exact control. These requirements have been successfully met by the direct-current series-wound motor, especially when used in combination with the modern system of series-parallel control. As, however, this system of control involves the use of re-

*In connection with Mr. McFarland's article it will be interesting to refer to the paper by Mr. Paul M. Lincoln, elsewhere in this issue, entitled "Interurban Electric Traction Systems—Alternating-Current vs. Direct-Current."

AN EXPERIMENTAL CAR, EQUIPPED WITH WESTINGHOUSE SINGLE-PHASE MOTORS, USED AT THE EAST PITTSBURG WORKS OF THE WESTINGHOUSE COMPANY, FOR DEMONSTRATION OF THE ADVANTAGE OF THE SYSTEM.

sistance in series with the motors, speed control is obtained only at a sacrifice of economy. It possesses, in fact, but two "running" points of full efficiency, namely, with motors in parallel, and with motors in series, with resistance cut out in both cases. At all other points energy is wasted in the resistance. This condition limits continuous operation to two running speeds, as it is impracticable to equip a car with resistance of sufficient capacity for continuous service.

With the alternating system a more economical control is possible, as speed variation is obtained by a change in voltage, which does not involve the use of the series resistance. This system possesses the further advantage that it permits economical operation at any speed within the capacity of the motors.

In general, the new system includes a transmission of current from a central power station at any desirable voltage. Static transformers of standard type reduce the potential to that selected for the trolley line. These transformers may be located at convenient points, and sub-station attendants will not be needed, thus greatly reducing the cost of operation.

As the system is single-phase, a single circuit only is required. The advantages of the present direct-current system in this respect are, therefore, retained, while the possibility of high potentials will greatly lessen the cost of line construction. A transformer on the car again reduces the voltage, thus making it possible to wind the motors for a low potential. In this way the problems of insulation are greatly simplified, and the dangers of short-circuit and motor burn-out are reduced to a minimum. The presence of a transformer on the car between the motors and the line practically eliminates danger to the motors from lightning or other static disturbances.

Alternating-current single-phase motors have been designed by the Westinghouse Company, and will be manufactured in sizes of 50, 75, 100, and 150 horse power. Twenty-five cycles have been adopted as standard, thus conforming to existing practice for power circuits. Motors adapted to lower frequencies are also practicable, and indeed the first experimental single-phase motors were constructed for 2000 alternations per minute.

The field of the alternating-current series motor consists essentially of a laminated core of circular punchings of soft steel, securely bolted together and held rigidly within a cylindrical frame of cast steel. End bells, accurately fitted and bolted to the frame complete the motor casing. Lugs are provided on the casing for the motor suspension and for the support of the gear case. Brackets for the armature bearings form a part of these end bells. Solid cast-iron bearing shells with babbit linings are used for the armature shaft. The axle boxes are horizontally divided and babbit-lined. Oil and waste lubrication is used throughout. The upper caps of the armature bearing are cast solid with the frame. The lower caps are securely held by bolts. Axles and wheels may, therefore, be removed without disturbing the motor. The gear cases are of standard design.

The laminated field core contains inwardly projecting poles of rectangular section. The field coils are held in place by simple and easily adjusted hangers, and are wound with copper strap, bent on edge, and insulated after being formed.

The armature consists of a drum-type core, with open slots, wound with machine-formed coils of copper strap, connected in multiple. The coils are held in place by retaining wedges of hard fiber which fit in grooves punched in the armature teeth. There are no band wires over the core. The brush-holders are of the sliding shunt type with carbon brushes.

An exhibition car equipped with motors of this type has been in operation at the Westinghouse Works at East Pittsburg, Pa., for many months, and has fully demonstrated the practicability of the system. These motors have a capacity of 125 horse power each, on the basis of standard railway rating.

The illustration on page 99 gives a view of the experimental car. The equipment includes:—four motors, complete with pinions, gears and gear cases; one main auto-transformer; one light transformer; one balancing transformer; one induction regulator; one regulator switch; one reverse switch; one motor cut-out switch; one circuit breaker; two resistance grids; two master controllers; one series motor for air compressor; three junction boxes; four seven-point connection sockets; one seven-point connection jumper; one storage battery consisting of 14 cells; and one Westinghouse air brake equipment, complete.

With the exception of the two master controllers, all the apparatus is mounted underneath the car body. Two motors are mounted on each truck. The connections are arranged in pairs, each pair consisting of two armatures in series and two fields in series. The two pairs are connected in multiple.

Across the two pairs of armatures a balancing or equalizing transformer is permanently connected, with its middle point connected to the points of connection of the two armatures forming each pair. This arrangement insures equal voltages on the four armatures under all conditions of service.

The car transformer reduces the trolley voltage to about 300 volts. From the car transformer current passes to the induction regulator, the design of which is such that a potential of 100 volts above or below that of the transformer may be obtained. In this way a speed variation over a wide range is secured, and by a method which gives a high economy at any speed. Any position of the controller may be used for continuous running. In this respect the new system possesses a decided advantage over present practice.

The regulator is operated pneumatically. Air for this purpose is supplied by the compressor which also feeds the air-brake cylinders. All switch-operating cylinders are controlled by electro-magnetic valves, actuated by current from the storage batteries.

A point which must be emphasized in connection with this new motor is that its elements have all been tested by years of use. It contains no untried features, although the combination is decidedly novel. The genius of Lamme found the way of overcoming what had long been considered insuperable difficulties. So far from there being trouble with sparking at the commutator, there is decidedly less under severe loads than with direct-current motors.

The exhibition car at East Pittsburg has been tested repeatedly by prominent electrical engineers who have had every opportunity to observe the working of the motors and of the alternating-current system under all conditions of service.

It has been pretty generally known that the projected electric road from Baltimore to Washington is to be equipped with this system, and it had been expected that the road would be in operation by the autumn of 1903. Complications due to the depression in Wall Street have delayed the work temporarily, but it will be carried to completion ere long. But for this delay the new system would by this time have been for several months in everyday use, and its merits would have been demonstrated to the general public.

The St. Louis Exposition

ALL things appear to work to the end of making the St. Louis Exposition stand in a class by itself. In magnitude and scope there has never been anything like it.

The Columbian Exposition at Chicago ten years ago, until the present enterprise was launched and its magnitude was apparent, was supposed to have fixed a standard for all time to come. That theory has been thoroughly exploded by the marvelous accomplishments of the Louisiana Purchase Exposition. The World's Fair at St. Louis covers 1240 acres of ground. All of Chicago's exposition was contained in 633 acres. Not in mere size does that present enterprise surpass all others. The great exhibit palaces differ from any constructed for former expositions. They are all revelations in the architect's art. The big, rectangular buildings of the past have been superseded by a group of wonderfully beautiful and symmetrical structures, assembled in the form of a lady's open fan. Collectively, they are many times larger than any other group, and for architectural beauty they immeasurably surpass anything the world has ever seen. The architects departed from beaten paths, and sought and found new features which they happily combined with the best examples of the architecture of other days.

When the plans and dimensions of the buildings were first made public the people were amazed at the daring of the exposition management. Even were such mammoth buildings erected, where would the exhibits necessary to fill them come from? Now that the buildings are all finished, and the work of installing the exhibits is under way, the question is answered. Even were the buildings three times as large, they could not contain all that has been offered. Inner courts have been roofed over, and where exhibitors have asked for thousands of feet of space they have had to content themselves with hundreds of feet.

Such being the case, the exhibitors and the exposition management have been enabled to exercise a discrimination that could not have been possible ten years ago. Official figures show that in the decade following the Columbian Exposition the value of the manufactured products has increased 50 per cent. Thus the world's storehouses contain treasures that were never before accessible. In the close discrimination that has been observed only the best and most worthy have been accepted, and each exhibit will represent the best in its class.

The exhibit of the Philippine Islands, which covers 40 acres, and has been created at a cost of about $1,000,000, is an exposition in itself. The foreign nations have never put forth such great exertions to make interesting exhibits. The keen rivalry that has been manifested between the most powerful nations is reflected in the exhibits from the newer and smaller countries. China is making such preparations as it was never deemed possible for that exclusive nation to consider. Fifty-one States and territories and more than that number of foreign countries are working in unison to make the Universal Exposition complete in every detail.

At this time no doubt exists about the fair being finished in every particular. The show palaces are all ready and the exhibitors are installing their exhibits. The roadways are practically all made. The intramural railway, encircling the grounds, is ready for the rolling stock and the application of power. The landscape is so advanced that a few weeks in the early spring may see it perfect, even though all work should cease until that time. The weather at St. Louis has been so mild all fall, and thus far in the winter, that but few days have been so cold that work out of doors was impracticable.

The General Electric Company has established a Drafting Room Apprenticeship Course, to which young men who are able to pass a satisfactory examination in arithmetic are eligible. The course is intended to fit applicants for drafting room positions.

Further information can be obtained by application to Mr. J. W. Upp, Engineer in charge of Drafting Room, General Electric Company, Schenectady, N. Y.

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Long-Distance Transmission of Energy

At High Electrical Tension

By M. H. GERRY, Jr., General Manager of the Missouri River Power Co., Helena, Montana

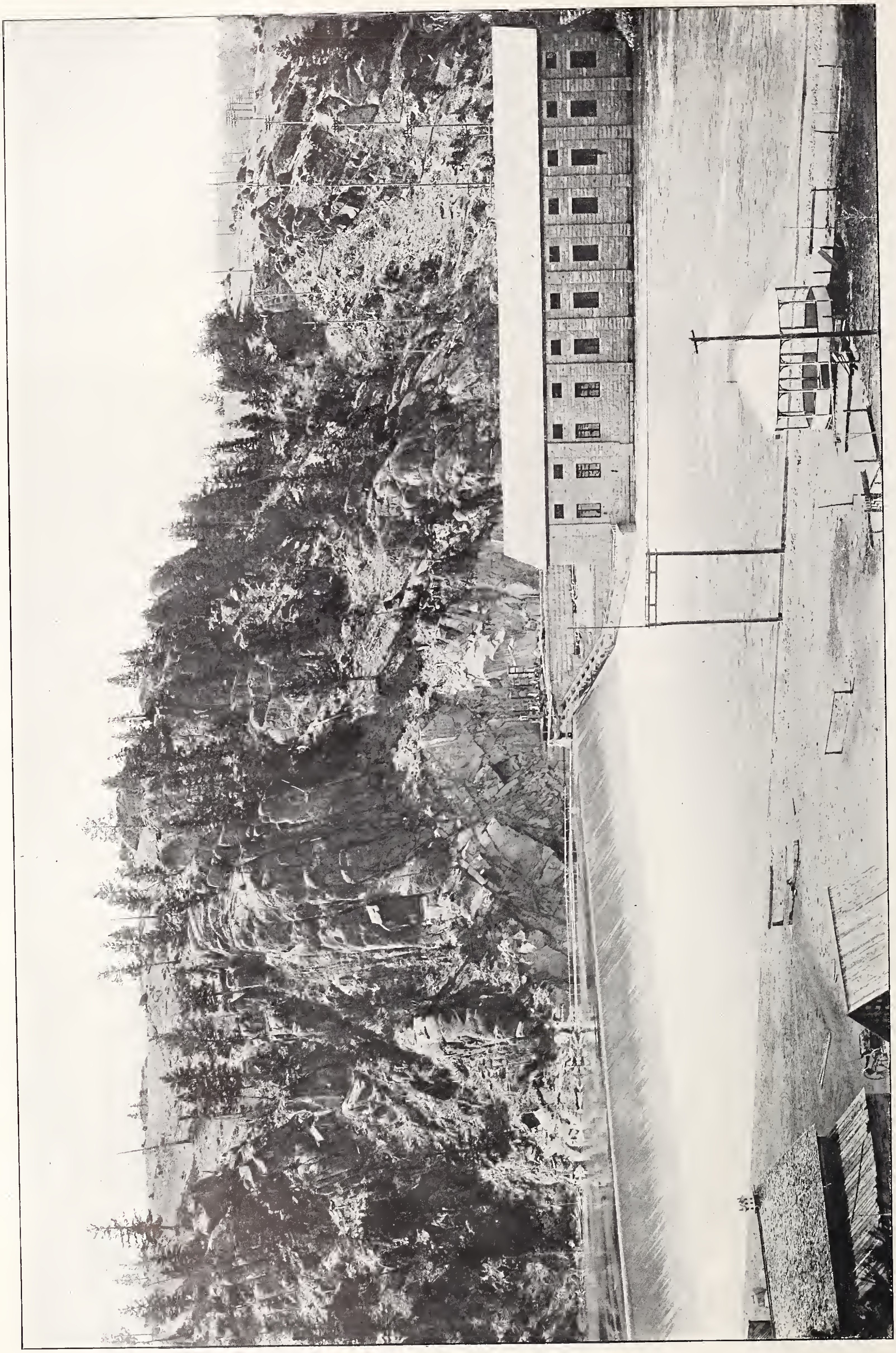
THE 57,000-VOLT DOUBLE TRANSMISSION LINE OF THE MISSOURI RIVER POWER COMPANY AT THE SUMMIT OF THE CONTINENTAL DIVIDE, 7,300 FEET ABOVE SEA LEVEL, WHERE THE LINES PASS FROM THE ATLANTIC TO THE PACIFIC SLOPE

THE discovery of the elementary principle of transmitting mechanical energy by means of electrical currents from one dynamo machine, used as a generator, to another, employed as a motor, is claimed for Hippolyte Fontaine as a discovery made at Vienna in 1873, although it is probably of earlier origin. Marcel Desprez, by a series of experiments in 1881, directed attention to this branch of electrical engineering and demonstrated that energy could be transmitted electrically over considerable distances. The first commercial electrical transmission of any size is said to have been constructed in Switzerland, under the direction of C. E. L. Brown.

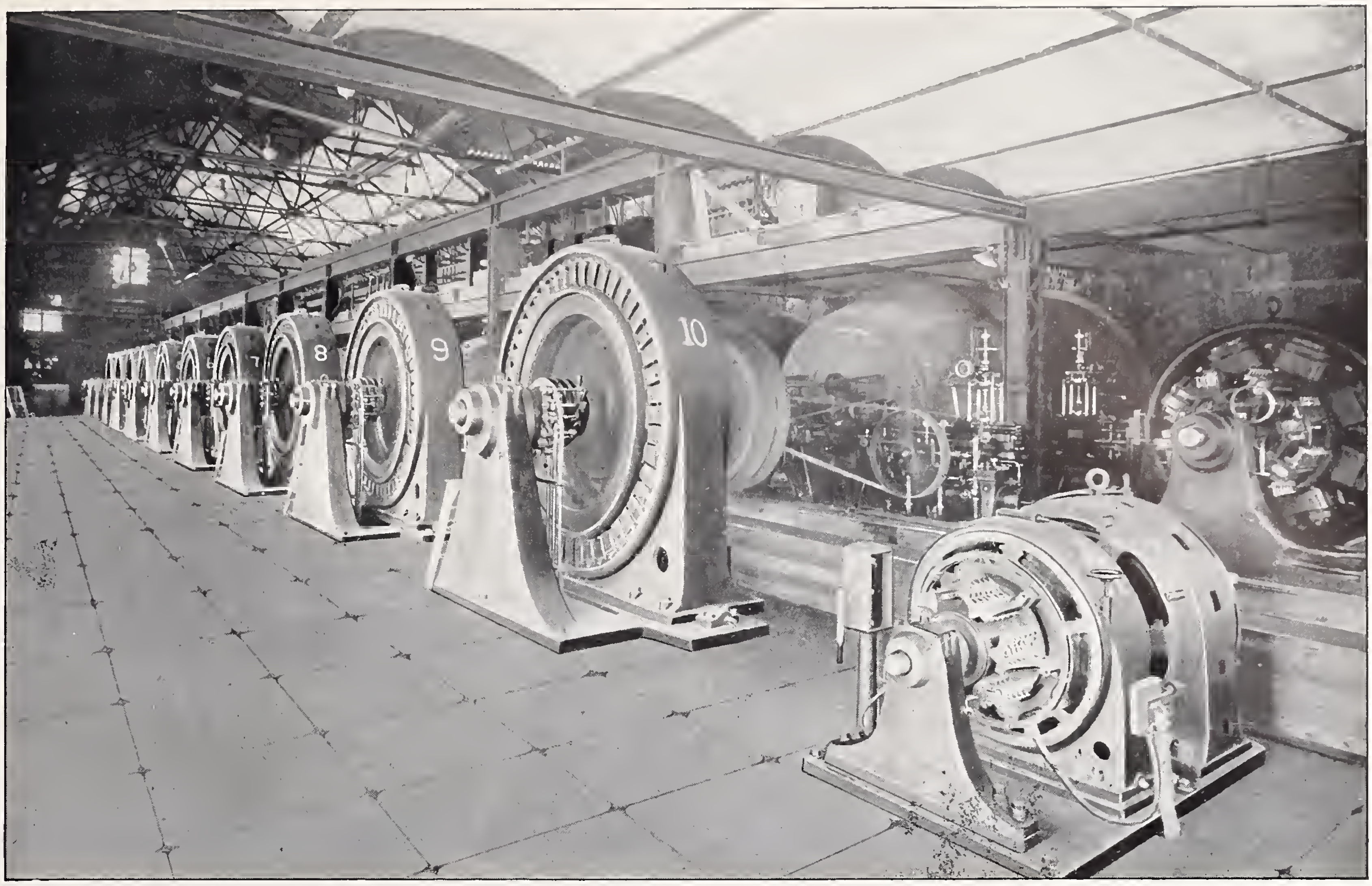
All of the earlier transmissions were undertaken with direct-current systems, but limitations in this direction were soon found, and electrical engineers turned to alternating currents for a solution of the problem. The advantages of the alternating system were recognized, but a great obstacle was presented in that no practicable alternating-current motor had been developed. Professor Ferraris in 1888, and Nikola Tesla, about the same time, developed in a primary form, a rotating field motor employing two or more alternating currents of the same period, but differing in phase relations. Dobrowolsky and Brown, together with other engineers both in Europe and America, soon developed this device into the present forms of induction motors.

With the invention of the induction motor, the most serious obstacle to the use of alternating currents for the transmission of power was removed, and the development from that time became quite rapid. At the Frankfort (Germany) electrical exhibition in 1892, the long-distance transmission from Lauffen to Frankfort, operating at 30,000 volts, was brought prominently to the attention of engineers, and it became evident that such transmissions were feasible, if the engineering details were properly worked out.

Power is transmitted long distances for the same commercial reasons as are manufactured goods and materials. It was found that in certain places, owing to the existence of water-falls, an abundant supply of



TEN THOUSAND HORSE-POWER ARE AVAILABLE IN THE POWER HOUSE OF THE MISSOURI RIVER POWER COMPANY AT CANON FERRY, MONTANA.



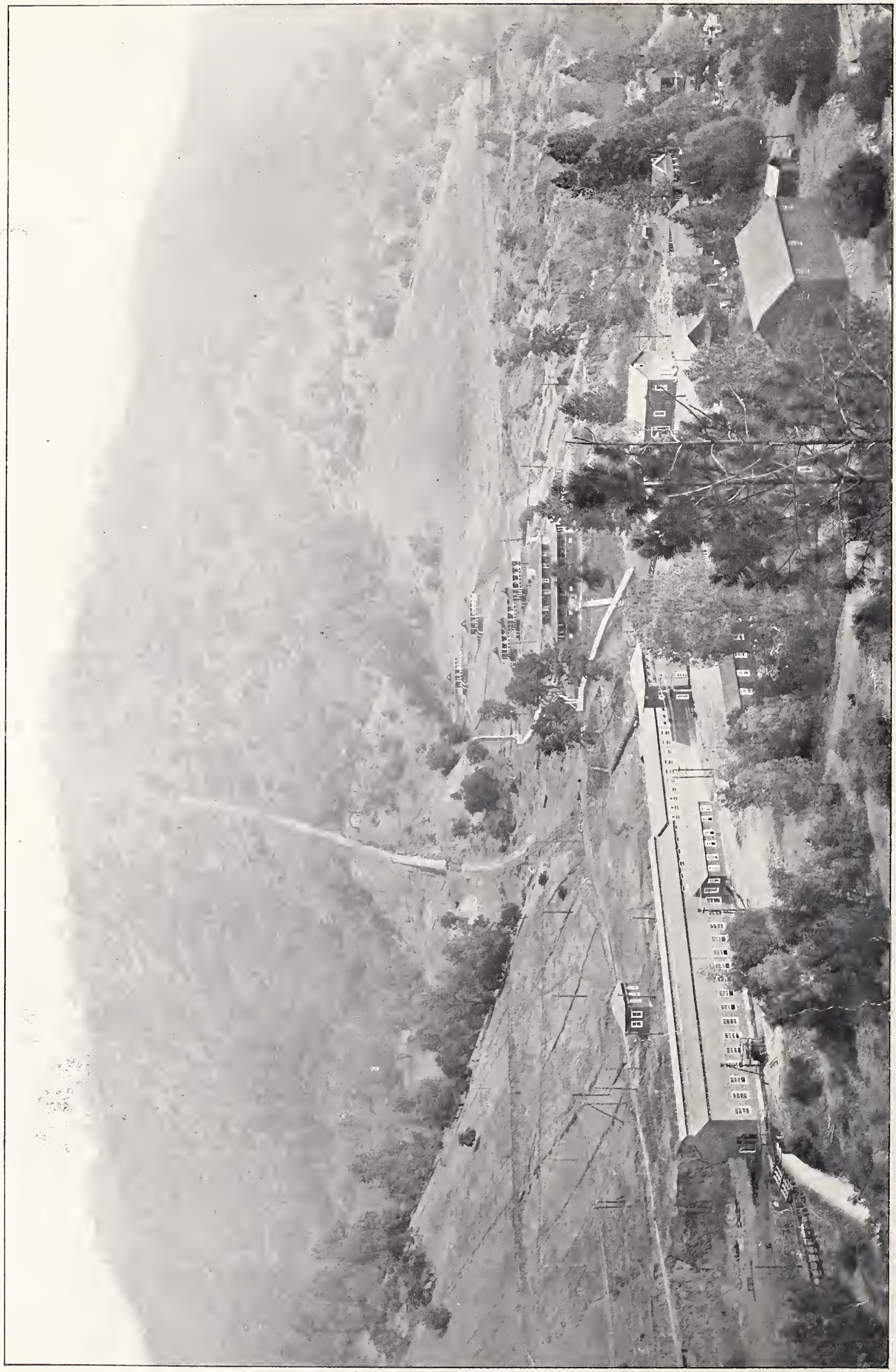
THE INTERIOR OF THE CANON FERRY POWER STATION

cheap fuel, or for other reasons, power may be produced in large quantities at a low price. This being the case, an electrical transmission becomes feasible whenever a market for the sale of the power is found at points within a practicable distance. As a commercial enterprise the generation and transmission of energy involve the problems of manufacture, transportation and sale, embracing economical production, efficient transmission, and a market where the product may be sold at a profit alike to the consumer and producer.

The object of nearly all the transmissions thus far constructed has been the utilization of energy obtained from water-power at points distant from the place of development. From the earliest times water-falls have been regarded as among the great sources of power, well suited to the uses of civilized man. Before the day of electrical transmission this source of mechanical energy had been used only at points near the place of generation. There existed a few examples of transmission by means of ropes, compressed air, and other mechanical devices; but the efficiency attained was low, even for the short distances undertaken, and the performance generally was unsatisfactory, except under special conditions. Many water powers were so situated as to be of little value for commercial purposes, and this fact constantly appealed to the brain of the inventor. When electricity came into use commercially for lighting and other purposes, engineers at once appreciated its possibilities as an available agency for the transmission of energy over considerable distances, but the practical application was long delayed, awaiting the development of a proper system, and the production of materials and apparatus suitable for the purpose.

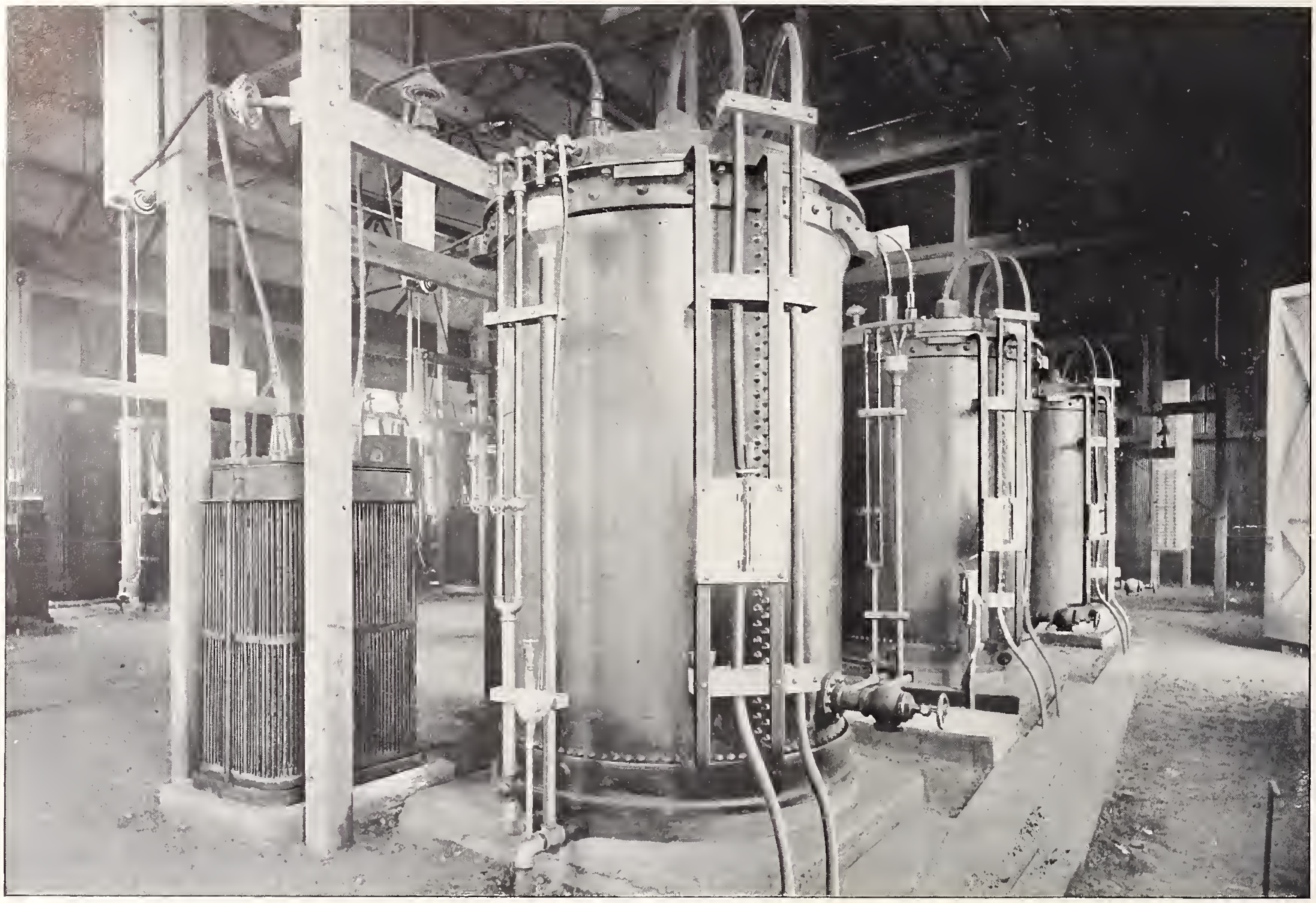
Lighting was the first commercial application, on a large scale, of electrical currents requiring considerable

THE TRANSMISSION LINE AT 7,000 FEET ELEVATION. A CHARACTERISTIC ROCKY MOUNTAIN REGION



A VIEW OF THE POWER HOUSE OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA, AT ELECTRA, SHOWING ALSO THE ROUTE OF THE PIPE LINE

TWENTY-MULE TEAMS WERE NOT UNCOMMON IN HAULING MACHINERY OVER THE MOUNTAINS FOR THE STANDARD ELECTRIC COMPANY OF CALIFORNIA



THE HIGH-TENSION TRANSFORMERS IN THE BUTTE, MONTANA, SUB-STATION OF THE MISSOURI RIVER POWER COMPANY

amounts of energy. The direct-current system came into general use for this purpose although there were many early experiments with alternating current. It soon became apparent, however, that aside from the many problems of the electric light as such, there was an underlying question involving the transmission of energy, and that if the energy were to be transmitted for this, or any other purpose, this question must first be disposed of. Because of certain inherent advantages for transmission purposes, alternating currents from this time began to come into use, and has ever since continued to gain in favor over direct-current systems.

The history of the electric railway is similar to that of electric lighting. At first, only direct current was used, on account of its apparent simplicity and ready application to motors: at a later day, however, the problem of the transmission of energy was found to enter very largely, and alternating current came into use for transmission purposes on long lines, although such current is afterwards converted into direct current for application to the cars, this having been done solely because, until latterly, no satisfactory alternating-current motor had been developed for traction purposes.

From what has been said, it may seem that there is considerable advantage in the use of alternating current for the purposes of transmitting energy. This advantage arises almost entirely from one feature of the alternating system, and that is the ease with which the electrical tension, or voltage, may be increased or decreased, by means of simple and efficient apparatus. While this is easy of accomplishment with alternating current, it is comparatively difficult with direct current. The amount of electrical tension employed is the fundamental condition controlling the economical transmission of energy by means of electrical currents. With low tensions of a few hundred volts, as are employed directly in lighting and electrical traction, there can be no commercial transmission of energy over any great distance. With any given tension and a fixed percentage of loss, a distance is finally reached where the cost of the conductor becomes too great, and power transmission is then impracticable.

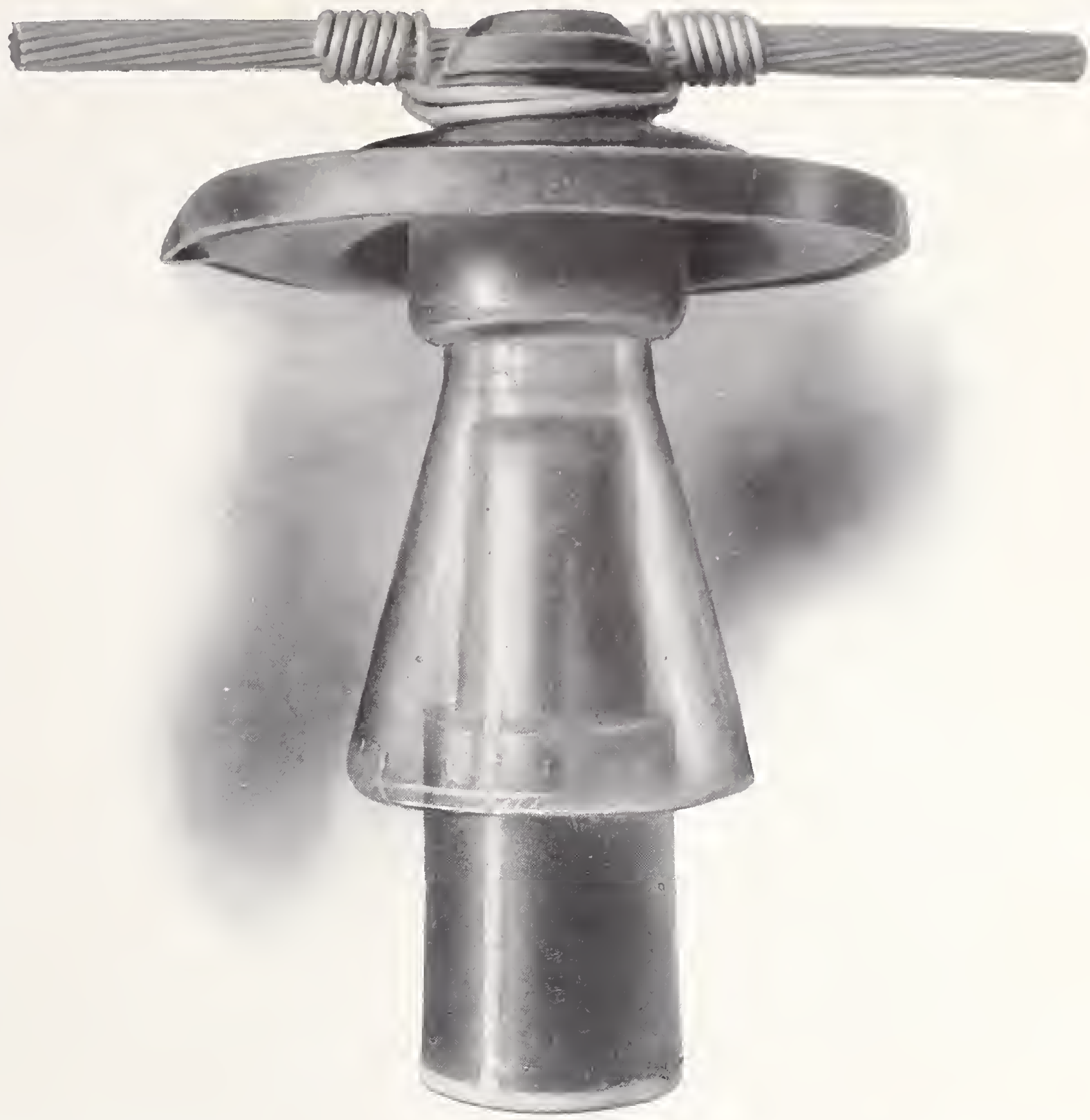
The great advantage of high tension being apparent, there has been a continual increase in the pressures utilized, but this has not been accomplished without many difficulties having been overcome. With tensions of a few thousand volts, it was comparatively easy to insulate both the transforming apparatus and the line, but with higher tensions the troubles increased, necessitating new designs and materials. The principal difficulties were experienced with the transformer and line insulation.

A great improvement was effected by the introduction of oil as an insulating material for transformers, and practically all transformers operating above 30,000 volts are now of the oil-insulated type. It was found, also, that in large transformers special means must be taken to remove the heat, and this has been accomplished in modern apparatus either by a forced air blast, for transformers operating at moderate tensions, or by water circulation through coils immersed in the oil, for high-tension transformers. A great deal of scientific and experimental investigation has been devoted to the insulation of transformers, and a number of new materials have been developed which produce such excellent results in connection with oil insulation, that manufacturing companies are willing to guarantee apparatus of this nature, at the present time, to withstand 100,000 volts operating pressure. When it is considered that ten years ago almost

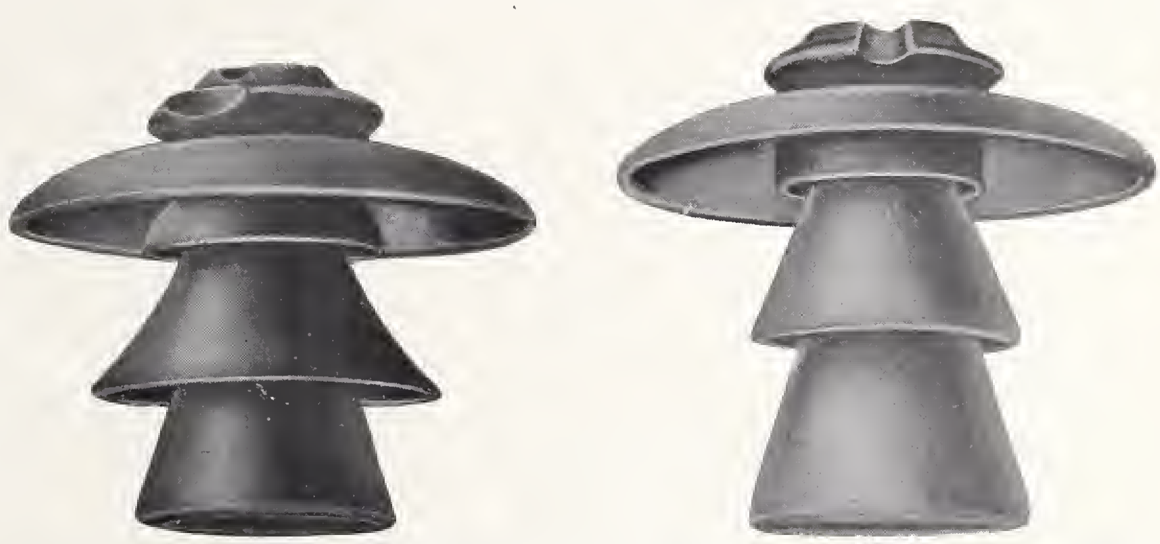
the maximum tension for which apparatus could be obtained in America was 10,000 volts, the progress which has been made in this direction will be appreciated.

Second to the insulation of the transformers, the greatest difficulty was experienced with the insulation of the line. In the early experiments at Lauffen and other points in Europe, an attempt was made to utilize oil in the insulators, but it was soon discovered that this was impracticable, owing to the accumulation of dust, leakage, etc., and it has long since been abandoned. By improving the quality of both porcelain and glass insulators, it has been found that either of these materials may be made to fulfill the requirements for line insulation up to the highest tensions employed. Porcelain possesses greater mechanical strength, but it is more difficult of manufacture and more costly. Glass gives excellent results, but until recently has been difficult to obtain in the shapes and sizes required for insulators for very high tensions. At the present time there are a number of plants operating around 40,000 volts, some of them using glass and others porcelain insulators. There is a transmission operating in Canada at 50,000 volts employing porcelain insulators, and one in Montana at 57,000 volts, employing glass insulators.

High-tension lines should be constructed throughout with the utmost care,—the wires placed well apart, the grading of the pole tops carefully attended to,—in order to remove as far as possible the mechanical strains. Where feasible, such lines are often located on a private right of way, from which all timber and other obstructions are removed; and as a rule, where the nature of the service is important, the lines are duplicated, so that in case of an interruption on one line the other may be in readiness to maintain the service. It is necessary sometimes to locate transmission lines on railroad rights of way, or even along the public highways, but this is not desirable where it may be avoided. There are, however, a number of important transmissions in the West which are so located.



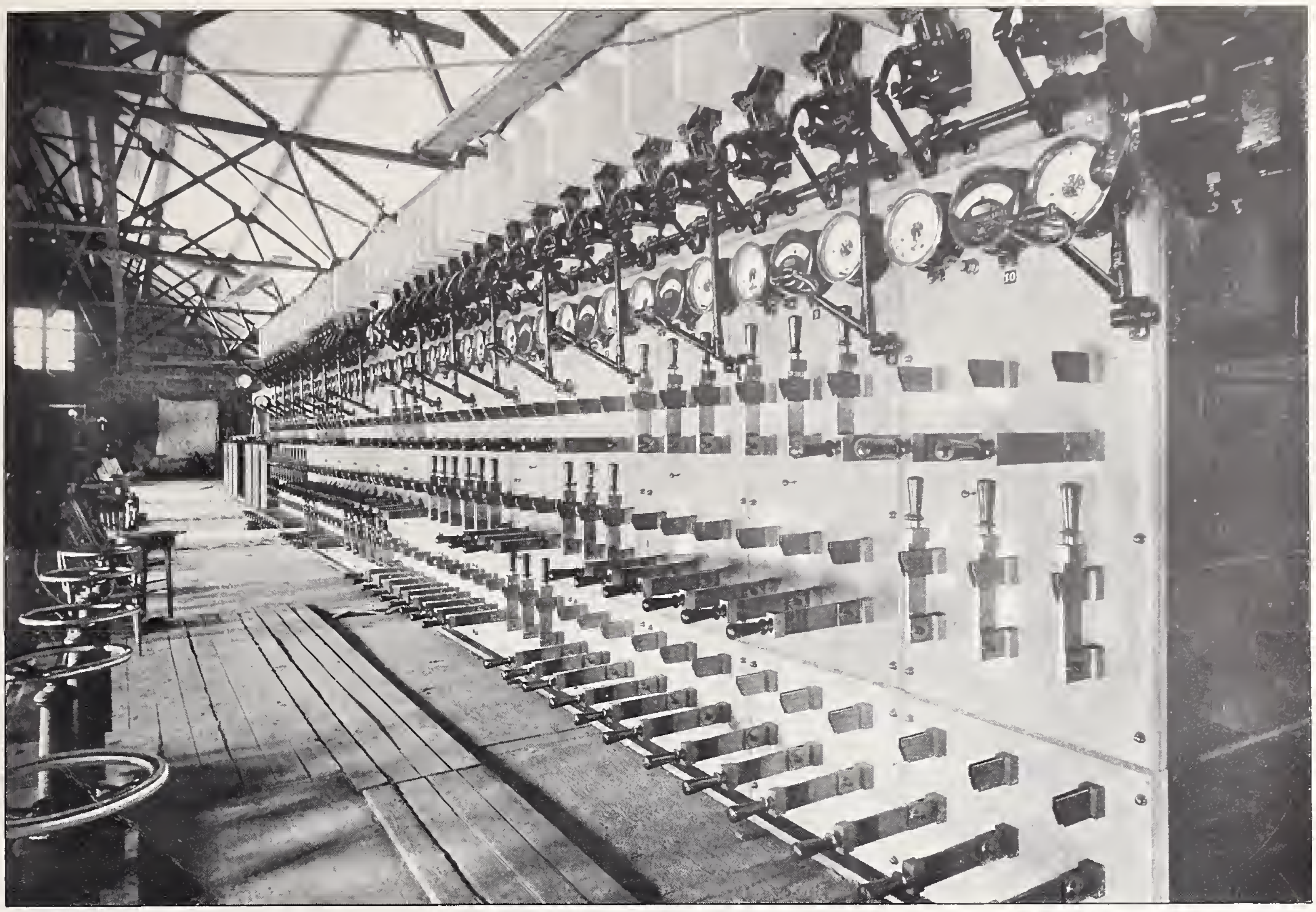
STANDARD INSULATOR, ALUMINIUM CABLE AND TIE, AS USED ON THE MAIN LINE OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA.



TWO ADDITIONAL TYPES OF INSULATORS USED FOR 60,000-VOLT CURRENT ON THE BAY COUNTIES AND STANDARD ELECTRIC COMPANY TRANSMISSION LINES. ALL THESE INSULATORS WERE MADE BY THE LOCKE INSULATOR MANUFACTURING COMPANY, VICTOR, NEW YORK.

As already stated, a pole line designed for high-tension currents, and for continuous service, should be carefully designed and of the best material and workmanship. It has been customary in the past in constructing such lines to use the best quality of cedar poles, extra heavy wooden cross-arms, and either metal or wood braces. These make a substantial and reliable form of construction at a reasonable cost; but on account of the importance of some work undertaken and its magnitude, still more permanent and costly forms of construction are being advocated, and some plants are now building that employ steel towers in lieu of poles, and are making use of an entire metal structure, with the exception of the insulators, for supporting the circuits. It is probable that some form of steel structure will ultimately supersede the present wooden construction, wherever the undertaking is of sufficient magnitude and importance. While nearly all high-tension transmission lines have heretofore been placed above ground, the recent advances in constructing underground cables for high tensions render it probable that this form of construction may ultimately be used very largely instead of the present overhead methods. Except for the difficulty of insulation, underground cables have great advantages.

THE CANAL AND HEADGATES FOR THE CANON FERRY POWER HOUSE



THE SWITCHBOARD IN THE GENERATING STATION AT CANON FERRY

In addition to the power wires, a telephone circuit is sometimes placed on the same poles for convenience in communicating between the generating station and the point of delivery, and also as a means of communication between various points along the line. In the early plants a great deal of trouble was experienced with these telephone circuits, but this difficulty has been almost entirely overcome, and a satisfactory telephone service may be maintained on the same poles with power circuits carrying the very highest pressures. It is customary for power companies engaged in the transmission of large amounts of power to maintain a complete telephone service connecting the plants, sub-stations, and even the large consumers.

In addition to the improvements in transformers and the lines, there have been advances in recent years, in the design and construction of auxiliary apparatus, including lightning arresters and switching devices for high tensions. Such details are of the greatest importance in connection with work of this kind, which requires very reliable service and freedom from all interruptions. At one time lightning was a most serious obstacle in the operation of all transmission lines, and it was thought that it would never be possible to operate such lines continuously during periods of severe electrical atmospheric disturbances. This has been overcome, and with care and the proper adjustment of apparatus, transmission lines may be made to operate in a successful and reliable manner under all weather conditions. The improvement in switching apparatus has been made such that high-tension currents may be handled and transferred with the same reliability as currents of but a few hundred volts. These improvements, and many others of a minor nature, have made the operation of electrical transmissions trustworthy and feasible for the longest distances, under the most exacting conditions.

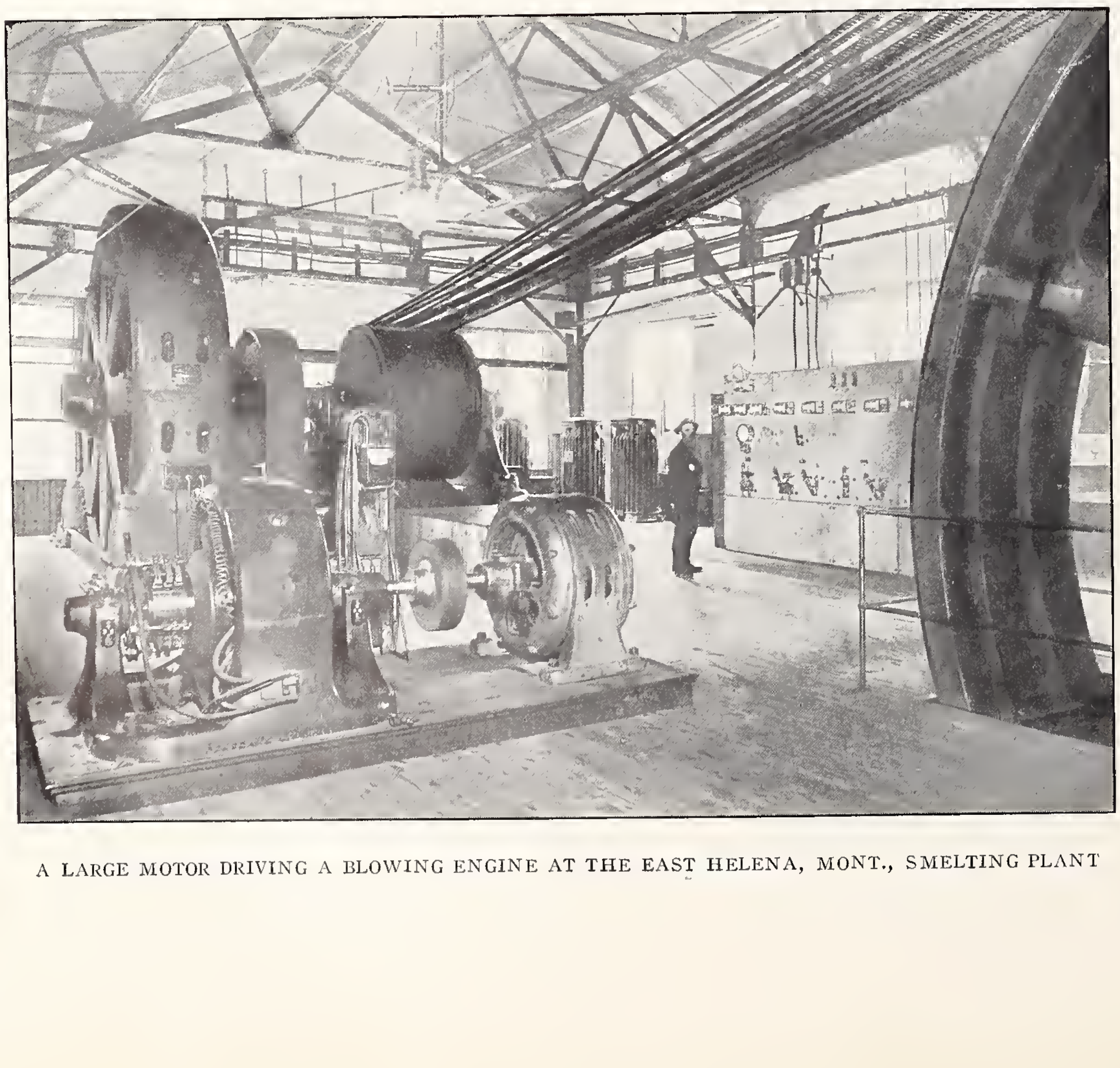
The first requirement for a successful transmission is a cheap and reliable source of energy. Up to the present time this has generally consisted of a water power development. Such powers vary widely in their nature, from what are known as low-head plants, where the amount of water is large and the fall comparatively small, to high-head plants, where only a small amount of water is available, but the head is very great. Water powers are developed in different ways. Low-head powers generally utilize dams, often combined with short canals, deep wheel-pits and tunnel tail-races. High-head plants usually employ long flumes, or canals, together with pipe lines designed to sustain great pressure. Low-head plants have been in use for many years, the apparatus and machinery are more or less standard, and have been improved in detail only to con-

ONE OF THE HIGH-TENSION INSULATORS OF THE MISSOURI RIVER POWER COMPANY, MADE BY THE HEMINGRAY GLASS COMPANY, COVINGTON, KY.

THE 57,000-VOLT DOUBLE TRANSMISSION LINE OF THE MISSOURI RIVER POWER COMPANY NEAR THE BUTTE SUB-STATION. IN THE BACKGROUND THE MAIN RANGE OF THE ROCKY MOUNTAINS CAN BE SEEN, CONSTITUTING THE CONTINENTAL DIVIDE. THE LINES ARE MADE UP OF SIX COPPER WIRES

form to the requirements of electrical service. Many of the high-head transmission plants are situated in the western part of the United States. Nearly all high-head plants employ some form of impact water wheel, the water being directed to the wheel by means of nozzles controlled by suitable governors. Such wheels operate at high speeds and produce higher efficiencies than are developed by the turbine type of wheels almost universally used for low heads.

Between low-head developments which have usually been considered as limited to about 100 feet, and the high-head developments of between 500 and 2,000 feet, there are numbers of moderate-head plants working within the limits mentioned. The design of these plants has been a combination of that employed for the high and low developments, usually combining dams with moderate length canals, or large pipe lines, and sometimes wheel-pits and tunnels. A variety of turbines is often employed, but differing materially from the designs for low heads, as the greater water pressures necessitate much stronger construction and higher speeds. In some instances plants of moderate head employ water wheels of the impact type, but as a rule these are small installations.



A LARGE MOTOR DRIVING A BLOWING ENGINE AT THE EAST HELENA, MONT., SMELTING PLANT

In modern power plants the electrical generators are usually directly connected with the prime movers, whether steam engines or water wheels. This requires that the electrical generators be designed for the same speed. With water wheels the speed depends, to a certain extent, upon the head employed, but this may be varied with the design of the wheel. Alternating-current generators, usually of the three-phase type, are universally employed for transmission purposes. Such machines are of the simplest construction, and in service give excellent results, with a very small amount of deterioration or repairs. The revolving parts are usually mounted either directly on the water wheel shaft, or on an extension of this shaft, connected through a coupling. In the older plants the current was generated at compara-

tively low pressure, rarely exceeding 1,000 volts; but in most of the later plants this pressure has been increased, in some cases to 10,000 or 15,000 volts at the generator. The high pressure entails a greater strain on the insulation, but the advantages in other directions, in the way of simplified construction, reduced dimensions of the bus-bars, conductors and switches, etc., more than offset the disadvantages due to the higher pressure.

From the generators the current passes through the switching apparatus to the transformers, where the electrical tension is increased to the extent required for transmission. After the pressure has been increased at the transformers, the current is conducted through other switching devices to the transmission circuits. At this point are connected the lightning arresters, which are designed to carry off static charges from the atmosphere.

At the end of a transmission line the power circuits are usually conducted to a sub-station, in which are located transformers for reducing the electrical pressure for distibution, or for direct application to motors or other apparatus. Besides the transformers, there are ordinarily placed in the sub-station lightning arresters similar to those in the main generating station, and also a switching arrangement for both the high-tension transmission and the low-tension distribution. The distributing lines from the sub-station may be either underground or overhead.

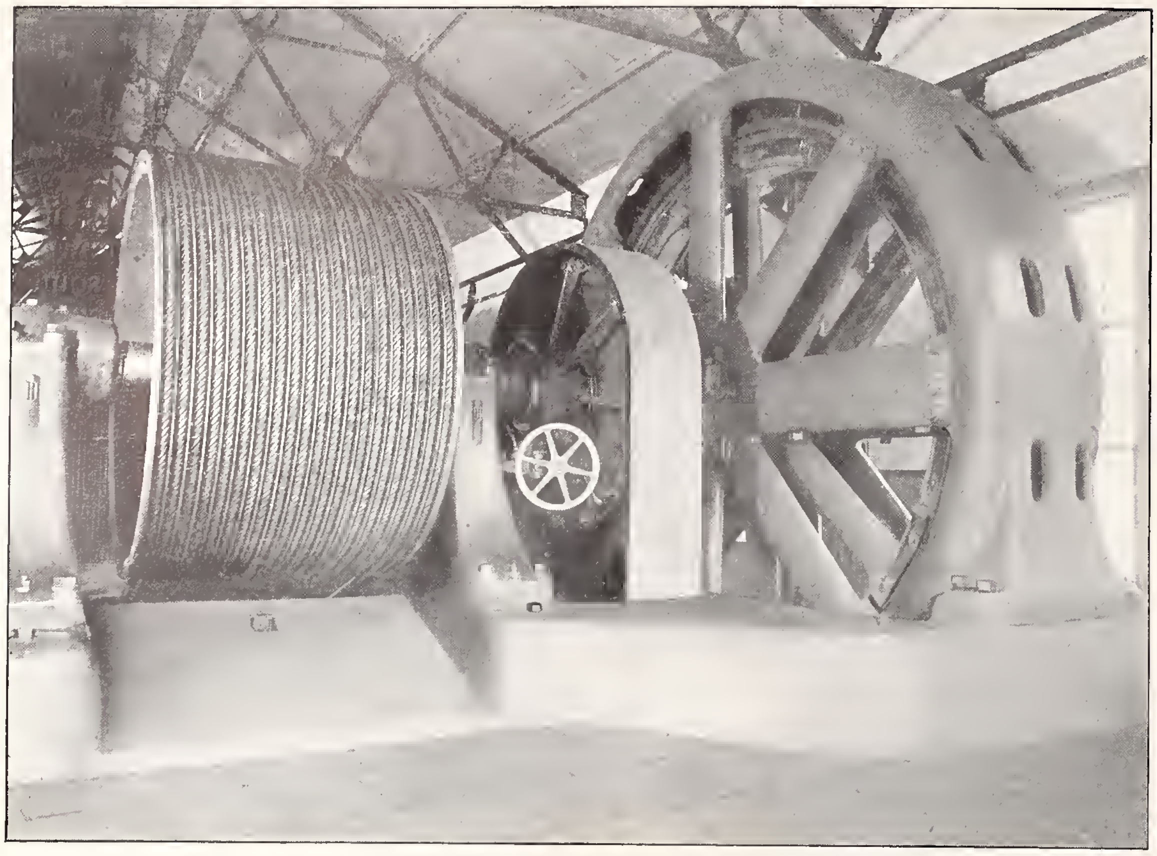
The practical applications of electrical energy are numerous and varied. In the West, where are located most of the long-distance transmissions, a great deal of power is used for mining, ore milling and smelting operations, including the concentration of ores, the operation of air compressors, blowers, hoists, mine pumps, and other similar machinery. In some sections considerable power is used for pumping water for irrigation, and large amounts are employed for lighting, operating electric railways, and miscellaneous power uses. Electrolytic and electrochemical operations consume a constantly increasing amount of transmitted energy, and in every line of industrial activity new applications for electrical power are being found.

The trend of development in power transmissions is towards higher tensions and longer distances. About 60,000 volts are the maximum tension now utilized in commercial service, but within a few years much higher tensions will be employed, and there will be in operation transmission lines longer than any now in existence. Commercial transformers can be obtained at present from manufacturing companies, suitable for 100,000 volts, and there are no serious obstacles in the way of the use of this tension when the conditions are such as to warrant the installation. There are, in truth, difficulties to be overcome, but they are only such as are met with in advanced engineering construction in any line. Each year brings more knowledge towards the solution of electrical problems and an increasing tendency towards better and more reliable forms of construction. The business of transmitting power is increasing rapidly and future development is fraught with great possibilities.

There are still a great many undeveloped water powers, inaccessibly located, which can be profitably utilized in the future. Besides water powers there are large deposits of coal which, owing to their low grade and the high cost of transportation, are now of little value. If these deposits were utilized locally and the power thus generated were transmitted some hundreds of miles, they would become of great value. This great field, now almost unoccupied, gives promise of future development, and awaits only a more intimate knowledge on the part of engineers and the public of the methods and results of high-tension electrical transmissions.

LIGHTNING ARRESTERS IN THE PLANT AT CANON FERRY

In electrical railroading, on a large scale, high tensions must play an important part, as the fundamental problem is that of the transmission of energy. With a solution of this



ONE OF THE 800-HORSE-POWER SLOW-SPEED INDUCTION MOTORS FOR WHICH THE MISSOURI RIVER POWER COMPANY FURNISH CURRENT

problem at hand, it requires only the perfection, in detail, of suitable motors and appliances to render practicable the operation, by electrical methods, of freight and passenger railway service of all classes. The change to electrical power would result in reducing operating costs and in improving the conditions of railway transportation. The financial outlay would be very great, but when viewed in the light of the present industrial development, even this may not long delay the adoption of electrical power.

From what has been said it appears that mechanical energy can be produced at the lowest cost per unit in large plants favorably located, and that high-tension electrical transmission renders possible the delivery of this energy with small loss, in any amount, at a large number of points distributed over a wide area. By affording an efficient method of delivery, it makes practicable, from a commercial standpoint, the wholesale manufacture of power. This is in line with the present era of specialization, in accord with the spirit of the age, and with American methods of industrial economy.

It is estimated that more than 35,000 arc lamps are in use on Manhattan Island. In addition to lighting streets, public buildings, armories, etc., in New York City, these lamps are used for almost every imaginable class of business and under all conditions of service.

Proposed Electric Railways in Cuba

IN a report to the Department of State, Max J. Baehr, United States Consul at Cienfuegos, Cuba, states that Cienfuegos has railway communication with Habana, Matanzas, Cardenas, Sagua la Grande, and Caibarien on the north coast, with Santa Clara in the interior, and thence, since the completion of the new Cuban Central Railroad, with Santiago.

A project is now under consideration by local and American capitalists for the construction of an electric railway extending from Cienfuegos into the interior, a distance of 30 miles or more, which would give rapid transit between that city and several important villages in the sugar-producing belt, these towns now having very inadequate communication with this port. Mr. Baehr states that he is credibly informed that a company has been organized to carry the project into effect, that a charter has been applied for and obtained, and that only a short time will elapse before the beginning of active work on the grading of the road. If this enterprise is carried to fulfillment, as seems reasonably certain, it will not only give employment to a large number of laborers who now find steady work only during the sugar-grinding season, but will contribute in no small degree to the material upbuilding of this section of Cuba.

The company undertaking this work is the Cienfuegos, Palmira & Cruces Electric & Power Company, with headquarters at Cienfuegos.

The Electric Light in Canada

AT the close of June, 1903, there were 324 electric-lighting plants in Canada, with 14,780 arc and 1,212,861 incandescent lights. Taking an arc light as equal to ten incandescent lights, there were 1,360,661 lights in use—or an increase in twelve months of 236,865 lights, or over 21 per cent. Of the 324 electric-lighting plants in use throughout the Dominion, Ontario possessed 203. Thirty-four municipalities supplied themselves with electric lighting. The province of Quebec, in spite of its enormous water powers, has not adopted this system of illumination to anything like such an extent as Ontario. At the close of June, 1903, it had 53 plants, 3853 arc, and 409,503 incandescent, lights. During the past five years, however, it has made rapid gains. On the average, also, Quebec plants are larger than those of Ontario. The largest plant in Canada is in Toronto, with 170,000 lamps (each arc light being taken as equivalent to ten incandescent), next to which comes the Lachine Rapids Hydraulic Company, with 158,503 lights, and the Ottawa Electric Company, with 111,927.

During the five years from 1898 to 1903, Manitoba increased its arc lights from 162 to 373, and its incandescent lights from 13,800 to 31,905. The largest comparative provincial increase has been in Britsh Columbia, arc lights having increased to 377, or 82 per cent., and incandescent to 74,297, or 257 per cent. In 1897 the Maritime Provinces had 95 arc and 46,977 incandescent lights; while in 1903 they had 1267 arc lights, an increase of 33 per cent., and 93,120 incandescent lights, an increase of 98 per cent.

The possibilities of radium as a Christmas gift were exploited by a certain up-to-date jeweler in London in rather a novel manner. He had manufactured a number of spinthariscopes of the size of a finger-ring case, mounted in a more or less expensive manner, depending upon the price. From $10 to $50 were cheerfully paid for these commodities, which were to serve as Christmas presents for scientific friends. The spinthariscope as supplied consisted of a small tube fitted with a lens and opening for the eye, and contained a microscopic quantity of radium. Upon looking through the lens in a darkened room, the full beauties of fluorescence which radium is capable of producing were seen.

Overhead High-Tension Distributing Systems

By H. B. GEAR, General Inspector of the Chicago Edison Company

IN reviewing the development of the electric lighting industry during the past decade, one is impressed with the gradual evolution of methods employed, which has culminated in a general era of consolidation during the latter years of the decade.

One of the results of this consolidation has been the redesigning and reconstruction of the previously existing distributing systems of electric lighting and power companies. Systems supplied by small plants and covering areas of two or three square miles in extent were merged into one great system, supplied from a common generating station, the original stations being converted into distributing sub-stations. In these great systems there were merged, in some cases, as many as twenty-five small ones, the consolidated system covering as much as 100 square miles of territory.

The extent of the area covered by the consolidated system introduced problems of transmission which did not exist prior to this era, since the distances covered were not beyond the economical radius of the feeders distributing current from any station. Transmission lines were, therefore, constructed for the purpose of conveying large amounts of energy economically from the large central station to the various centers of distribution whence the small areas had previously been supplied.

In many cases the small distributing systems whose territories were adjacent had been competitors and had lines covering the same territory. The first result of consolidation was, therefore, the removal of superfluous transformers and pole line equipment. Feeders were rearranged and all load was transferred to one set of mains, the best pole line of the two being preserved. Secondary mains were also necessarily rearranged and in some cases entirely reconstructed to accommodate additional load which was placed upon them.

The methods of transmission and distribution which were adopted by the absorbing companies for use in the reconstructed system varied in different localities according to the previously existing conditions. As a result, the following methods are to be found in use in large distributing systems throughout the country:—

1.—Single-phase generators, transmission lines and distributing feeders.

2.—Two-phase generators, three-phase transmission lines, single-phase and two-phase distributing feeders.

3.—Three-phase generators and transmission lines, single-phase and three-phase three-wire distributing feeders.

4.—Three-phase four-wire generators and transmission lines, with single-phase and three-phase four-wire distributing feeders.

The first of these systems is not employed by any very large central station company except in the city of St. Louis.

The advantages of three-phase current for transmission lines and power distribution are such that the three-phase system is more advantageous where there is a considerable distance to be covered and a field for the sale of electric power. The chief advantage of the single-phase system over others is the simplicity of wiring and operation of the station and distributing system. But feeders and transmission lines must have 33 per cent. more copper in this system than in the three-phase system under given conditions.

The second system combines the use of two-phase and three-phase lines, and is in use in a number of large cities, such as Philadelphia and Brooklyn. The chief advantage which this system claims over the pure three-phase system is greater ease of maintaining balance of the load, since there are but two phases to balance on the distributing bus instead of three. The use of two-phase distributing feeders requires the same amount of copper as is needed for single-phase feeders, but allows the use of polyphase motors in the sale of power.

The current which is transmitted three-phase is transformed again to two-phase at the distributing sub-station to secure the ease of balance which is desired at the generating station. A disadvantage of this system is that special transformers, sensitive in their regulation, are required for the transmission system.

The third system which employs three-wire three-phase generators and transmission lines is also employed in a number of large cities, such as Boston and Cleveland. This system has the advantage of economy of copper in both transmission and distributing feeders where three-phase distributing feeders are employed. Single-phase feeders may also be used where the load is chiefly lighting, by balancing them from the three phases at the distributing sub-stations. The use of three-phase distributing feeders for lighting purposes is subject to the serious disadvantage that if potential regulators are used they must be so connected that the operation of one regulator affects the pressure of two of the three phases at once. This makes it necessary to adjust two regulators in order to produce a desired change of pressure on any given phase.

The last of the above mentioned systems, namely, the use of four-wire three-phase generators, transmission lines and distributing feeders is the most recently developed and is therefore not in as general use as are the others. The principal cities in which this system is employed are Chicago and Cincinnati, the system in Chicago being the largest of this sort in the world. It is also among the largest distributing systems in point of area covered of any kind in the country.

The chief advantage of this system lies in the fact that the generator coils may be wound for 2,300 volts and Y-connected, thus giving a potential of 4,000 volts between either of the phase wires. The fourth-wire being connected to the neutral point of the Y, 2,300 volt single-phase feeders may be operated from neutral to either phase wire. These may be independently regulated with ease. Four-wire three-phase feeders may also be employed, with a regulator in each phase wire controlling the potential from either

phase wire to the neutral independently.

These four-wire lines, when approximately balanced, are, therefore, equivalent to 4,000-volt distributing circuits, using standard 2,300-volt transformers, and are capable of carrying four times as much load as three single-phase circuits under the same conditions. Three-wire branches may be taken off for power service at any point. This greatly widens the range of economical distribution of current from sub-stations, diminishing the number of sub-stations required and decreasing the sensitiveness of the feeders carrying lighting and power to fluctuations in the power load.

The use of compensated voltmeters has recently made it possible to operate these four-wire feeders with unbalanced loads with perfect success. The voltmeter in the station on this system indicates the potential at the end of the feeder or at any point on the system for which it is desired to regulate the pressure. The principal disadvantages of this system are the introduction of 4,000 volts on the same pole line with 2,200-volt circuits, and the necessity of hanging three transformers for the smaller power services in cases where the neutral wire may not have been extended.

The distribution from sub-stations is accomplished by means of single-phase feeders where the load is chiefly lighting and the distance not greater than a mile. The advantages of simplicity of wiring are greater than any saving which might be effected in copper by the use of polyphase lines. Where it would otherwise be necessary to run a number of single-phase feeders in the same general direction, a four-wire three-phase feeder is installed. Polyphase motors may then be connected anywhere within the vicinity of this feeder. In cases where the amount of three-phase power is small and scattered in a given territory, it is found desirable to connect all the lighting to one of the three phases, using a single regulator to control the pressure on that phase and running two small phase wires to supply the power load.

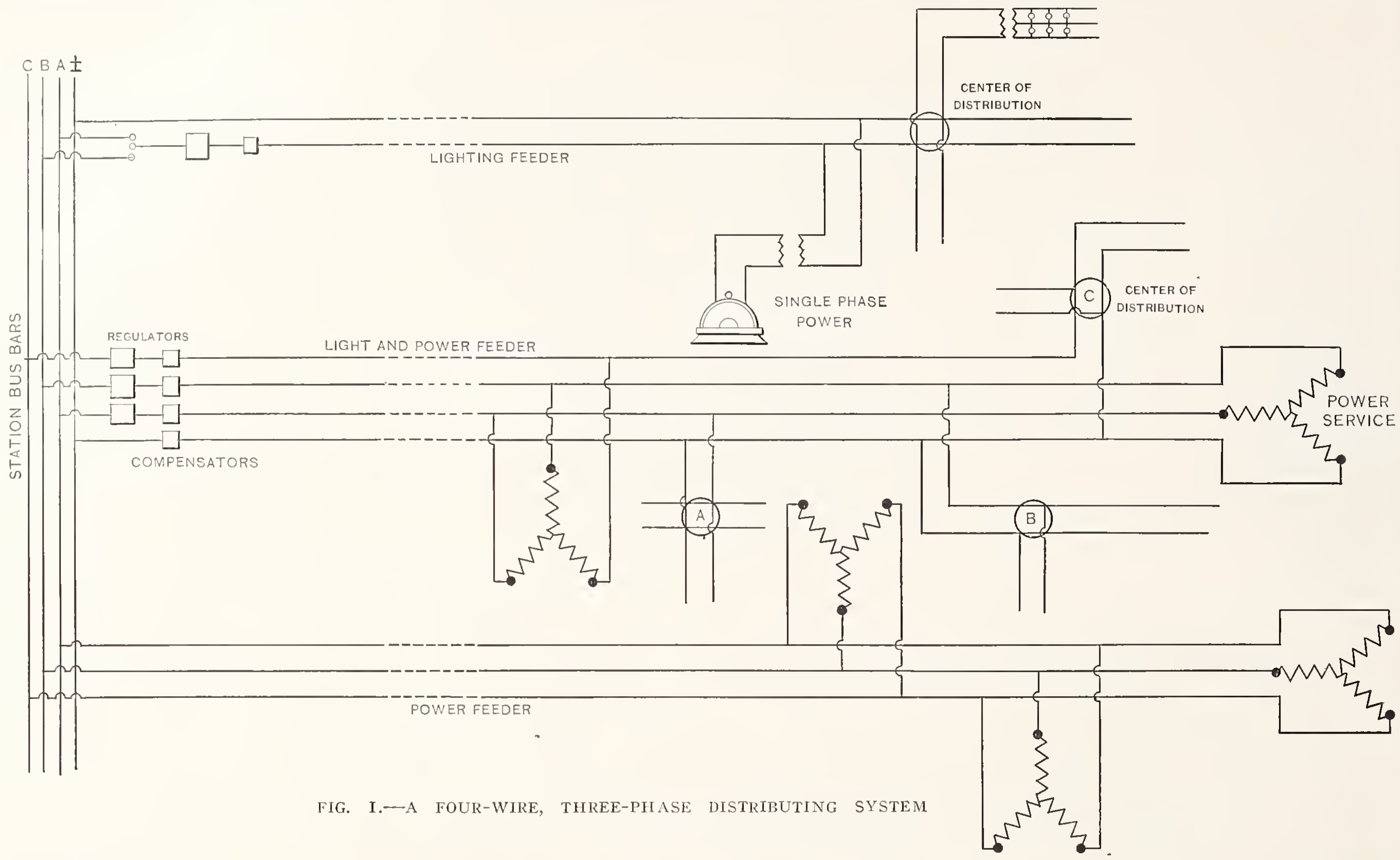


FIG. I.—A FOUR-WIRE, THREE-PHASE DISTRIBUTING SYSTEM

Where the power load is very heavy, it is preferable in some cases to operate separate circuits for power service in order to obviate fluctuations in the pressure of the lighting system due to varying power load.

The four-wire three-phase system seems to combine more advantages for the combined purposes of transmission, light and power distribution than any of the other above-mentioned systems. This system is therefore being installed in places where the previously existing conditions are such as to allow of its adoption. The various methods of distribution on this system are illustrated in Fig. 1.

In the course of the engineering work incident to the reconstruction of these old systems some problems have arisen which had not been given systematic treatment under the conditions of previous years, and others which were incident to the new conditions. Among these problems were the following:—

How should primary feeders and mains be arranged? and how much area should each feeder cover?

What should be the maximum load placed on any one feeder?

To what extent should secondary mains be employed in replacing individual transformers?

What should be the class of construction employed in pole-line work?

Two general methods of feeder distribution had previously been in use, —one in which a feeder was run to the district to be supplied, and from this feeder branches were taken off in either direction on the "tree" system. In the other method a feeder was run to a "center of distribution," from which point mains were radiated in all directions.

The first of these methods simplified the pole line construction somewhat, but was open to the objection that customers near the station were supplied with higher pressure than those further away. The second method insures approximately equal distribution of pressure, but involves duplicate wires running parallel to the feeders from the center of distribution back towards the station.

The advantages derived from good pressure regulation outweigh the disadvantages of extra wires, and feeders

are, therefore, designed in most cases according to the "center of distribution" method. The mains from the center of distribution must be so calculated with reference to their loads that there should not be more than 2 per cent. loss in pressure between the feeder center and the end of any main.

This method of distribution having been adopted, it becomes necessary to determine the required number of feeders to supply a given territory. This introduces the problem of the area which can be satisfactorily covered by one feeder and the maximum load placed upon it. The limitation of 2 per cent. drop in the mains fixes their length, this not exceeding 3,000 feet in most cases.

In a territory where the load consisted of small, scattered consumers, a feeder might supply an area of one to one and one-half square miles, while in condensed business and factory lighting the area would be much smaller, in some cases covering but a few blocks. The maximum load on a feeder is, therefore, fixed by the design of the main system in territory where the load is scattered, and may not exceed 75 kilowatts. In densely loaded territory the drop on the mains becomes secondary to other considerations, such as continuity of service, feeder losses, balancing of phases, etc. In such districts the maximum load should not exceed 200 kilowatts on a single-phase feeder.

In cases where polyphase feeders are used for carrying lighting load, the load may be from 100 to 200 kilowatts on each phase, according to the density of the load in the territory supplied.

The system of secondary mains is operated on the Edison three-wire system in most instances. The three-phase four-wire secondary system is used to some extent, but has not found general favor on account of the increased difficulty of balancing the three phases and complication of wiring.

The extent to which individual transformers are replaced by secondary mains, depends largely upon local conditions. In territory where the load is scattered and adjacent customers may be several hundred feet apart, it is frequently preferable to install individual transformers rather than to construct secondary lines, since the investment in copper becomes so great that the fixed charges are more than the losses in transformers.

It is impossible to lay down any rule which will be of general application for such cases, since the cost of energy varies with different stations, and the value of transformer losses is, therefore, different in different localities. In a system where the cost of energy is 1 cent per kilowatt-hour at the switchboard, it will usually be found economical to install secondary mains as soon as the load density reaches a point where it would be necessary to install two transformers within 800 or 900 feet of each other if secondaries were not used. Not more than 2 per cent. loss should be allowed in secondary mains. No wire smaller than No. 6 B. & S. gauge should be employed, and it is usually not economical to install wires larger than No. 2, except when the load is very heavy.

The maintenance of overhead high-tension distributing systems has not until recent years received the degree of intelligent attention which it deserves. Pole lines have been built with little regard to the economical necessities of the work, with the result that after standing a few years poles are pulled out of line and wires are allowed to stand slack, cross-arms resemble the limbs of a scare-crow and repairs are a frequent necessity.

The introduction of high-tension transmission lines and the four-wire three-phase system and the change in distribution voltage from 1,000 to 2,000, has forced more careful attention to these detils. Those who are entrusted with the care of the large distributing systems have, therefore, established a policy of line construction to govern their work and have placed in the hands of their men standard specifications according to which all line construction is to be performed. This has resulted in a uniform style of work throughout all parts of the larger distributing systems. The general practice of some of the companies operating large overhead high-tension distributing systems may be outlined as follows, details of arrangement which vary in different localities being omitted:—

Pole Line Material.—Pole line material should be selected with such care as will insure the use of first-class appliances in all particulars.

Poles should be as straight as possible, sound at the heart and not less than 7 inches at the top, with an increase in diameter of about one inch in 5 feet toward the butt. It is not considered that poles having tops smaller than 7 inches are strong enough to carry the load of cross-arms and transformers which are likely to be placed on any pole in a distributing system. Cross-arms should be of sound material, free from knots and sappy parts, and as well seasoned as possible. The painting of poles and cross-arms is of importance in urban work, chiefly from an æsthetic standpoint, although the life

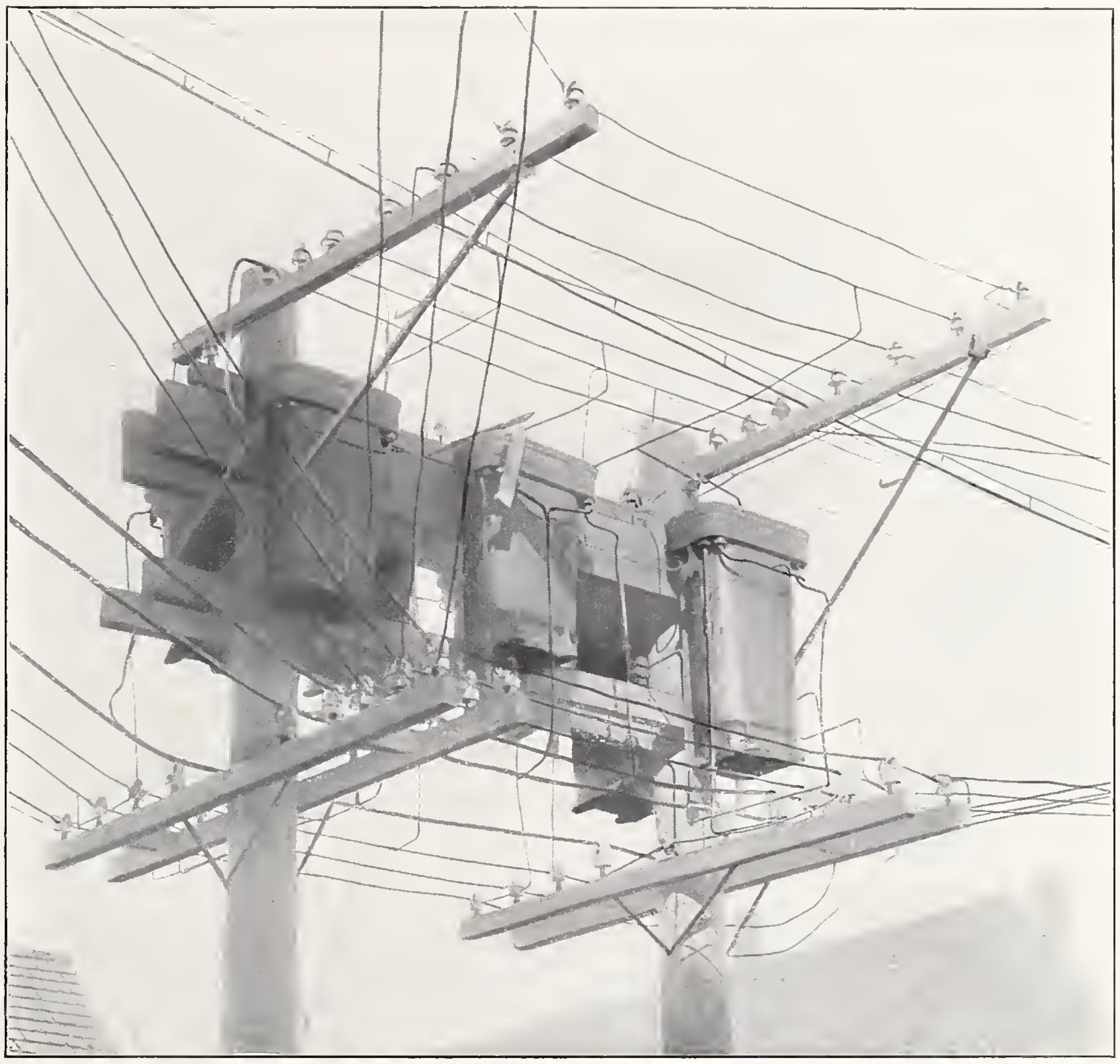


FIG. 2.—A METHOD OF ARRANGING LARGE TRANSFORMERS OVERHEAD

of a cross-arm is somewhat increased by the use of paint. This should be applied to cross-arms before they are installed.

Pins should be of sound locust, free from knots and dry rot. They should be of such dimensions that they will fit the holes in the cross-arms closely. A shank $1\frac{1}{2}$ inches in diameter is considered of sufficient strength for all ordinary work.

Braces, bolts, lag screws, and any other metal parts should be well galvanized to prevent rusting and should be free from flaws.

All guy wires should be of stranded steel with a tensile strength of about 80,000 pounds to the square inch.

Setting Poles.—Gains should be cut $\frac{1}{2}$ inch deep at intervals of 24 inches from center to center. The first gain should come 8 inches below the top of the pole. Poles should be set not over 125 feet apart.

In setting poles in unusually soft ground, or at corners where it is impossible to maintain a guy, a filling of cement should be placed about the pole, or planks 3″ x 1′ x 4′ should be attached to the pole beneath the ground in such a way as to support it. In filling the hole around the pole, the earth should be well tamped while the hole is being filled.

No cut-out boxes, lightning arresters, transformers or other apparatus should be located on any junction pole where it can be avoided.

Cable poles should be of extra size and, if possible, should be supported without a guy. The cables should be run up the pole in an iron pipe to the lower cross-arm and equipped with "pot head" joints between the lead cable and the line wire. The wires from the joint to the insulator should have extra heavy rubber insulation. No cut-out boxes or other apparatus should be located on the cable poles.

Stringing Wire.—Wire should be strung in as great lengths as possible to avoid unnecessary splicing. The tension placed upon the wire should be such that the sag of a span of 125 feet will not exceed the amounts shown in the following table:—

Temperature, Degrees, Fahr...	10	20	30	40	50	60	70	80	90
Sag inches	6	8	8	10	10	12	12	14	14

When spans longer than 125 feet occur, they must be given special consideration.

In arranging wires on cross-arms, the top arms should be occupied by transmission lines, feeders, series arc circuits, in which no lamps are taken in that neighborhood, and any other lines from which no taps are made. The lower cross-arm should be occupied by the service primary and secondary mains and the series circuits from which lamps are likely to be taken. Secondary mains should be run alone on the bottom cross-arm, if there are more wires than can be carried on one cross-arm.

Cross-Arms.—Cross-arms should be fastened to the pole by one $\frac{5}{8}$-inch through bolt, fitted with washers at each end, the nut to be placed on the side of the pole opposite the arm, and any extra length of bolt to be cut off after the nut is attached. Wherever lines are built in alleys, the alley arm should be used. The pins should be fitted to the arm before it is attached to the pole.

On all poles where there is an unusual strain, due to a change in the direction of the line or to the dead ending of wires, double arms should be put on.

Lightning Arresters. — Lightning arresters should be mounted on the cross-arm in such a way as to be as accessible for inspection and cleaning as possible. Special care should be taken in making the ground connection so that it is well made and not exposed to injury.

Fuse Boxes.—Fuse boxes should be mounted on the first pole away from the one on which the tap is made. All lines carrying 50 kilowatts or more should be equipped with cut-out boxes connected with copper wire. Where iron case fuse-boxes are used, they should be mounted on glass knobs on the cross-arms. Fuse boxes should be placed on the cross-arm as accessibly as possible and the wires arranged so as to make it as safe as possible.

Transformers.—Transformers should be hung on separate cross-arms below the other cross-arms, except where the size of the transformer and the small number of wires make it possible to make a good installation on existing cross-arms. In hanging transformers of 10 kilowatts or more, the pole should be double armed. Special construction is necessary in installing transformers larger than 25 kilowatts.

The problem of installing heavy transformers sometimes becomes one of serious importance. Sizes above 25 kilowatts are often placed in a manhole at the base of the pole. This is an expensive method of installation and is not necessary except in places where transformers must be placed in streets, where their unsightly appearance makes them objectionable to the public.

The installation shown in Fig. 2 illustrates a method of arranging large transformers overhead. The framework carries two 30-kw. transformers for arc lamps, two 20-kw. for incandescent lighting and three 15-kw. for three-phase power, a total of 145 kilowatts. The fuses for these transformers are all on adjoining poles, so that it is not necessary for a lineman to do any work about the installation with the wires alive.

In the streets of cities which are occupied by electric light, railway, and telephone and telegraph companies' lines, situations develop which result at times in a miscellaneous assortment of pole lines and wires on the same street. This is especially apt to be true at the intersection of main thoroughfares. Much can be done to relieve such situations by the use of joint pole lines. This places the wires on one good set of poles, reducing rather than increasing the danger from crosses between electric lighting and signaling wires. The signal wires should be below the lighting wires, as they are more likely to break than the lighting wires.

The maintenance of overhead lines is a matter of much importance. Incipient trouble may often be prevented by a system of inspection. Such inspections should be made every month on important lines, and every two months on all lines. Accidents to life and property may thus be avoided to a large extent, and the expense of maintenance reduced in the long run.

Electric Railroad Car Lighting in Germany

As a result of many tests of various systems of railroad car lighting in Germany, the Prussian State Railway Administration has finally settled on a direct system of lighting from a single generator with a steam-driven dynamo, located on the locomotive, under the control of the engineer; also auxiliary or regulating storage batteries placed on each car of the train, thus rendering the lighting system on each car practically independent, its lights being assured a constant supply of current from its own accumulators, which accumulators are kept charged by the dynamo on the locomotive. It is stated that this combination meets more perfectly than any of the others the requirements of simple, economical and efficient construction, maintenance and attendance in regular service.

The famous Eiffel tower, it is said, has commenced to lean to one side, and will therefore be taken down.

The Lake Superior copper output for December, 1903, was one of the largest ever recorded, having amounted to 17,325,000 pounds.

The Individual Application of Electric Motors to Machinery

With Rules for Determining the Size of Motors

By WILLIAM COOPER

THE technical press has been overrun with descriptions of the individual application of electric motors, and volumes have been written on the subject, describing various forms of application. There is, however, throughout all this matter a very great lack of data, or information in regard to the actual power used by the different machines to which the motors have been applied, or to which it is contemplated applying them. A great mass of data has been given; but these in most cases have been assumed. Very little of the information is the result of actual operation. It is usually given in the form of the motor being of a certain horse-power, as applied to a certain machine; but it is not reduced to any basis on which further calculations can be made.

As a result of all this there have been many applications of motors in which the motor has been out of all proportion to the work to be performed,—in some cases unnecessarily powerful, and in a great many cases too small. The last fault is especially pronounced in the so-called variable-speed motors as applied to machine shop tools. Quite a demand has sprung up for electrically-driven machine tools in the last two or three years, and a great many machine tools have been built with motors attached to drive them. In many cases these motors were mere toys, as compared to the work which they were expected to perform.

The favorite method of obtaining variable speeds is the field method of regulation. But a desire to keep the motor within a certain size, so that it would not be abnormally large in proportion to the machine to which it was to be attached, has led in many instances to the use of motors that are entirely too small when they are expected to yield a considerable range of speeds by field regulation. This condition of affairs is a handicap to the use of electric motors for variable speed work, as these failures are so numerous that they have brought this branch of the business into disrepute, and it is only the persistence of the demand for this class of machinery that keeps the business alive. The great difficulty and impossibility almost of operating a variable-speed motor on any one fixed and constant voltage through a range that is applicable to machine shop tools has led one electrical firm, prominent in the field of individual motor-drive, to absolutely refuse to fill orders of this kind.

The writer was called not long ago to inspect a lathe in the factory of a prominent machine tool manufacturer, which was equipped with a variable-speed motor. This motor was intended to have a range of speeds of four to one, these speeds being obtained by shunt field regulation, the motor operating on one fixed voltage. The motor behaved very badly, and the tool manufacturers were at a loss to account for its poor working. A test showed that the motor would not do the maximum work that it would be called upon to do even when running on its full field strength, and when running at its point of weakest field it sparked badly while the machine was doing no work. These are the cases that give motor-driving in general a black eye.

The inability of motor manufacturers to furnish a motor with a comparatively wide range of speed and operating on a fixed and constant voltage has led machine tool manufacturers to devise various forms of mechanical speed-changing devices. These devices fill the gap and make it possible to equip a machine tool with an electric motor which can be operated on a fixed voltage and yet have power enough to properly operate the tool.

The advent of the high-speed tool steels has also made the question of motor-drive in machine tool practice more difficult. It has also shown to the machine tool manufacturers that their tools have not the necessary pulling power to do the work that it is possible to do with these steels. The machines themselves in a great many instances are shown to be weak. With the best tool steel obtainable, prior to the introduction of the so-called high-speed steels, a 24-inch engine lathe with one tool could be made to use only three or four horse-power, while with some of the new steels the same machine will readily absorb three or four times this amount.

These are the points to which both the machinery manufacturers and the motor manufacturers must give strict attention if the business of individual application of motors is to advance as the qualifications of an electric motor for this work warrant. It behooves the machinery builders to guard against sending out machines equipped with motors that will not fulfill the conditions perfectly. It is far better to burden the machine with a complex set of change gears than to equip it with a variable-speed motor that is not able to meet all the demands which will be made upon it. The manufacturers of electric motors have, of course, to take the butt end of all the blame. So long as the motor is not capable of working the machine to its limit, the machine stands blameless.

The question of how much of the total range of speed variation of any given machine should be taken care of by the motor is a matter of opinion. The machine manufacturer naturally asks the motor manufacturer what range he can furnish. The motor manufacturer, anxious to make as good a showing as possible for his motor, and perhaps not knowing the conditions to be fulfilled, guarantees a wider range than the motor can cover and fulfill its functions properly. In this he is at fault. The greater the number of motors that are put out under these conditions, the slower the business will progress, and it is certainly poor business policy to furnish apparatus of this kind.

This question of equipping machines with motors that are unable to perform the work which they are called upon to do brings the motor-drive into disrepute in still another way. The motors which are thus overloaded burn out, and the machines to which they are attached are thrown out of service. This leads to the belief that motors in general are poor, weak things, and makes

the ordinary purchaser prejudiced against the apparatus as a class. It not only prejudices the purchaser, but it apparently affects the minds of people who are in a position to know, and should know, that electric motors, as constructed by the best manufacturers, are not toys or playthings, but machines to be thoroughly depended upon when properly designed for the work which they are called upon to perform. This is evidenced by the behavior of street car motors. Certainly no other class of machinery could be subjected to the same abuse and work under as adverse conditions as a street car motor and have anything like the life that this kind of motor has.

In a recent issue of one of the technical journals, in an editorial comment on the advisability of building the electric motor as an integral part of the machine to which it is applied, the following statement was made:—

"Unfortunately for the progress of electric machine tool driving, it is, in the present state of the art, bad design to make an electric motor an integral part of a machine tool. This condition exists because of the still primitive state of the electric motor, which makes it quite necessary to be able to quickly replace burnt out armatures, etc. If the armature is mounted on a shaft which forms a part of the machine, such as a lathe spindle, for instance, it is special, and its replacement is a matter of days or weeks, depending on the distance from the factory, their promptness, etc. But, if a standard motor is used, the replacement of a burnt-out armature, or of the entire motor, is a simple matter. If one make of motor is not available, another generally can be readily substituted. It is true that one of the first attempts at driving lathes with electric motors was made by building the motor in the headstock and mounting the armature on a quill which corresponds to the cone pulley, but this design was a failure. A stroll through the machine shop of an electric concern, well known for their efforts along these lines, will discover a number of engine lathes, originally built with the motors in the headstock, but now equipped with standard motors mounted on the field rings of the old motors. They found that their lathes were lying idle too much of the time, because of repairs to the motors, and so abandoned the idea. When some better means of insulating the windings of motors are discovered than is now known, it may be feasible to make them part of the machine tools; but it emphatically is not so now, except, perhaps, in the case of some small tools like grinders or drills."

ELECTRIC MOTOR HORSE-POWER CURVE, MULTIPLE VOLTAGE AND FIELD REGULATION

The statement that such motors were replaced is a fact, but the reason assigned is entirely erroneous. The writer has personal knowledge of the matter referred to, and can say positively that the reason these motors were replaced was because they were not powerful enough to do the work that the machine in which they were built was capable of doing. The construction, of necessity, required that the motor should have a maximum speed the same as the maximum speed at which the spindle of the lathe would be operated, and a minimum speed that would be called for by the slowest speed on the lathe. These limiting speeds would be, on a 24 or 30-inch lathe, a minimum of about 40 or 50 revolutions per minute, and a maximum of 250 to 300 revolutions per minute. The construction also limits the cubical contents of the motor. It is practically impossible to build into the headstock of a 24-inch lathe a motor of sufficient power to properly operate the machine. The inability of these motors to properly perform the work which they are called upon to do was made especially evident upon the introduction of the high-speed steels, and it was for this reason, and this reason alone, that the machines were altered.

Statements like the one quoted, appearing as leaders in prominent technical journals, do an injustice to the manufacturers of electric motors. It must be admitted, however, that some electric motors are placed upon the market which are not by any means perfection in workmanship and material. The same conditions exist in the manufacture of electric apparatus that exist in the manufacture of any class of machinery. There is always some apparatus of inferior grade on the market. However, it must be said that the modern electric motor, as built by the best manufacturers, is as reliable as any part of any machine to which it may be connected.

One more illustration of this eternal unfitness of things:—The writer recently received an invitation to inspect, in company with several others, who are directly or indirectly interested in such matters, a new motor-driven lathe. This lathe was built by one of the leading machine tool builders for an electrical manufacturing company, and, of course, was equipped with one of their motors. From what was said about the outfit, one expected to see quite a wonderful creation. What was seen was this:—

A 20-inch swing lathe with about a 10-foot bed. A motor of the semi-enclosed type mounted upon, and a little to the rear of, the centre line of the headstock, connected by a chain drive to an intermediate shaft, upon which was mounted a pinion that meshed into the main gearing in the headstock. The gearing was so arranged that by the manipulation of two levers, which operated friction clutches, four different speeds could be obtained, having a ratio of 3.2, that is, the second speed was 3.2 times as great as the first, the third speed was 3.2 times as great as the second, and so on. The gearing and clutches were all enclosed in a neat and compact manner, and all parts seemed to be of liberal proportions and in keeping with the balance of the machine tool. In fact, the lathe was a

fine example of its type and, together with the method of mounting the motor, made a very mechanical and neat appearance. The motor was said to be a variable-speed motor of 3 horse-power, having a speed variation of two to one by field regulation. The controller for the motor also contained armature resistance, the intention evidently being to increase the speed range of the motor to about three to one by the use of this resistance.

The first thing noted was that the motor sparked viciously when running at its maximum speed, taking full load current, and no work being done other than rotating the piece in the lathe and overcoming the friction of the machine. With a good operating cut on a piece of steel, the current was about four times the full load current, and the motor was threatened with destruction. There can be but one result in this case, as in many others like it,—the absolute failure of the motor to perform its functions, and the ultimate replacing of it by a larger one. In this particular case, a motor which would be capable of giving at least 10 horse-power at any point of its range would be none too powerful for this tool.

The important point to be determined in the individual application of electric motors is the maximum amount of power required to operate the machine and the conditions which will require this power. If the maximum power required be coincident with the maximum speed, and the amount of power decreases with the speed, a motor having field regulation is ill adapted to the work of furnishing different speeds. If the power required is nearly constant, or if it decreases as the speed increases, this method of regulation is much more applicable.

Having determined upon the condition under which the maximum power will be required, the next point is to determine the amount of power. This should be very carefully considered, as the successful operation of the machine will depend in a great measure upon it. In equipping machine tools with motors, if the kind of work which the machine is to perform is known, the amount of power required can be very closely determined.

In the case of an ordinary engine lathe, which will, without doubt, be used to turn steel shafting to some extent at least, the power required will be almost exactly proportional to the pounds of metal removed. This is true irrespective of the speeds or feeds used, while for machines to operate on cast iron, the amount of power required varies with the feed used. In working steel, the amount of power required is about one horse-power per cubic inch of metal removed per minute. This is very nearly correct for all ordinary working conditions, except in case of a milling machine using a very fine feed.

In machining cast iron the power required varies from two-tenths to one horse-power per cubic inch of metal removed per minute, depending upon the feed per tool. In some exceptional cases it may run even higher than this. A 20-inch swing engine lathe of modern design can easily take a cut one-fourth of an inch deep with one-sixteenth of an inch feed, and, using high-speed cutting steel, a cutting speed of 60 to 80 feet a minute can be easily maintained. This will call for from 11 to 15 horse-power. It is evident that the lathe above mentioned, which was equipped with a 3 horse-power motor, will hardly meet the requirements, especially when running on a weakened field.

Knowing the amount of power required to operate any given machine, and the conditions of the requirements, the next point is the selection of a suitable motor. If a constant-speed motor is to be used, the selection is a very simple matter. If a variable-speed motor is to be used, it may be quite different. In the first case it is only necessary to select a motor which will operate at a speed applicable to the machine; while in the second case there is not only one speed to consider, but several speeds, depending upon the range through which the motor is to operate.

If the behavior of a motor under various methods of speed regulation is fully understood, the selection of a variable-speed motor can be more intelligently made. There are certain rules governing the power of an electric motor, when operating at different speeds, depending upon the method of regulation. It is well known that the power of a direct-current electric motor decreases in inverse ratio as the increase of speed when the speed is increased by field regulation. It is also well known that the power of a direct-current motor increases in a direct ratio as the increase of speed when its speed is increased by increasing the volts impressed upon its armature. These rules are inflexible, if the same margins be maintained in the motor. To illustrate:—

Assume that a given motor, when operating on its normal voltage, has a speed of 600 revolutions per minute. If the speed of this motor be increased to 1200 revolutions, the load which it will carry with the same margin will be one-half its normal load. If its speed be decreased to 300 revolutions by decreasing the volts impressed upon its armature one-half, its power will be one-half the normal with the same margin.

However, the limiting condition in the two cases is not the same. In the case of its speed being increased by field weakening, the limiting condition will be its tendency to spark at the commutator. In the case of its speed being decreased by lessening the impressed volts, its limiting condition will be heating of the armature. If the motor normally had a margin of 100 per cent. in both heating and sparking, or, in other words, was capable of carrying double its rated load, it would carry its normal load under the above conditions. It is, therefore, necessary, if it is desired to increase the speed of a motor 100 per cent. by field weakening, to have 100 per cent. margin for sparking at normal speed, if the motor is to carry normal load at the increased speed. The same is true in regard to heating, if the speed is to be decreased by lessening the impressed volts.

These rules are graphically presented in the accompanying diagram. The change in speed and horse-power by change in field strength is represented by the curve *A*, while the change in speed and horse-power by change of voltage is represented by the lines *B*, *C*, *D*, etc. From this diagram we can determine the minimum size motor that will be required for any given case, using either shunt field regulation entirely, or combining shunt field regulation and multi-voltage, or multi-voltage entirely.

Suppose, for instance, that a given machine tool requires 1 horse-power to operate it under all varying conditions of service, and it is required to have a speed range of four to one. We can get this in three ways:—One by using entire field regulation, which will require a motor of 4 horse-power at 500 revolutions per minute with normal field strength; or, if two voltages are available,—one of which is double the other,—a 2 horse-power can be used running at 1000 revolutions at normal field strength, or one-fourth as large as the motor, giving this range by field control entirely; or this motor can be run at 2000 revolutions by increasing the voltage.

The horse-power of this motor, due to reduction in speed by reduction in voltage, will decrease along the line *K* in the diagram, so that at 500 revolutions it will give 1 H. P., and also give 1 H. P. at 2000 revolutions by weakening its field, following line *A*. It is seen from the curve that with two voltages,—one of which is double the other,—in combination with weakening the field, the range of speed of four to one is the maximum that can be obtained from a motor which will be worked to its full capacity at both

the minimum and maximum speeds. If any greater range than this is required under these conditions, a larger motor must be used. For instance, suppose that a speed range of five to one be required, and the variation obtainable by changing voltages is only two to one. Assume, as before, that the maxium speed is 2,000 revolutions per minute; the minimum speed will be 400 revolutions. Now, as 400 and 800 revolutions will be the speed variation by changes in voltages, these voltages being in the ratio of two to one (say, 110 and 220 volts), a motor will be required to develop 2½ H. P. at 800 revolutions on full field; this is indicated by the point at which the curve *A* crosses the ordinate of 800 revolutions. The horse-power of this motor will decrease, as that of all other motors, directly in proportion to its speed by reduction in voltage. It will, therefore, be 1¼ H. P. at 400 revolutions, being in this case slightly in excess of the power required at the slowest speed. The motor, however, in this case would be equivalent of a 3.1 H. P. at 1000 revolutions, or more than 50 per cent. larger than a motor to do the same work with a speed range of four to one.

A motor will be six times too large when operating at six times its speed, the speed being increased by an increase in voltage; in order to get the same range by shunt field regulation, the motor would require to be thirty-six times the size it would be if operating only at the one maximum speed. This, in itself, is sufficient proof of the superiority of the system of getting variable speeds by variable voltages over the system of shunt field regulation exclusively.

From this it follows that a motor whose speed is to be varied by change in voltage, field excitation remaining constant, will be directly proportional in size to the change in speed; while a motor whose speed is to be varied by change of field excitation will be in size as the square of the change in speed.

In conclusion, the writer would indicate a few rules to be used in determining relative sizes of motors for constant horse-power application. These are as follows:—

First.—The total range of speed, using both variable voltage and field regulation, will be as the square of the range of voltages.

Second.—The change of horse-power will be directly proportional to change of voltage on armature, field being constant.

Third.—The change of horse-power by change of field strength will be inversely proportional to change in speed, voltage on armature remaining constant.

Fourth.—The relative size of motor, as referred to the maximum speed, will be directly proportional to its speed variation when using variable voltages.

Fifth.—The relative size of motor, as referred to the maximum speed, will be as the square of the speed variation when using field regulation.

Electric Station Power Plant

The Advent of the Steam Turbine and Gas Engine

By ELIHU THOMSON

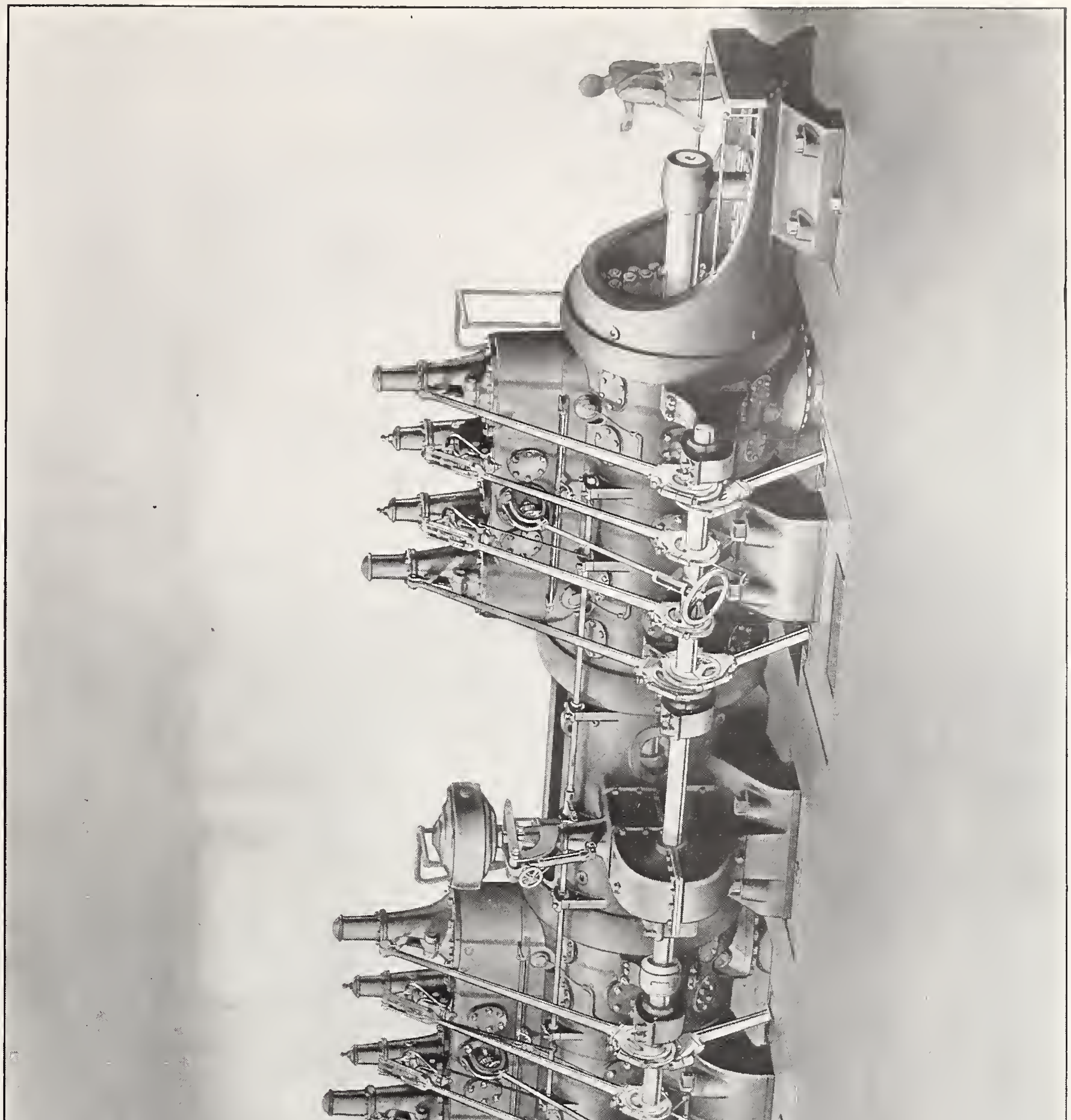
Dr. Thomson's brief review of what has been accomplished with electric generating plant during the past twenty-five years, presented a short time ago before the National Electric Light Association, clearly outlines what we may expect to see in the electric power station of the near future, to the exclusion, in great part, of examples of standard practice of the past decade. The steam turbine and the gas engine will certainly cut deeply into the field hitherto occupied almost exclusively by steam engines of the conventional type.—THE EDITOR.

TWENTY-FIVE years ago the electric station had its beginning. In 1878 a number of dynamos of the alternating type were belted to steam engines and used for lighting the Place de l'Opera and Rue de l'Opera in Paris. The practice of belt driving, in which the dynamo speed is much higher than the engine speed, was well-nigh universal for a period of ten to fifteen years thereafter. The earliest machines, which were direct-connected to the engine without belting, were probably the Edison Jumbo dynamo and the Gordon alternator, each of which was brought out in 1883. The machines up to that time were of very limited capacity. A dynamo that would use 25 to 50 horse power to drive it was one of large output.

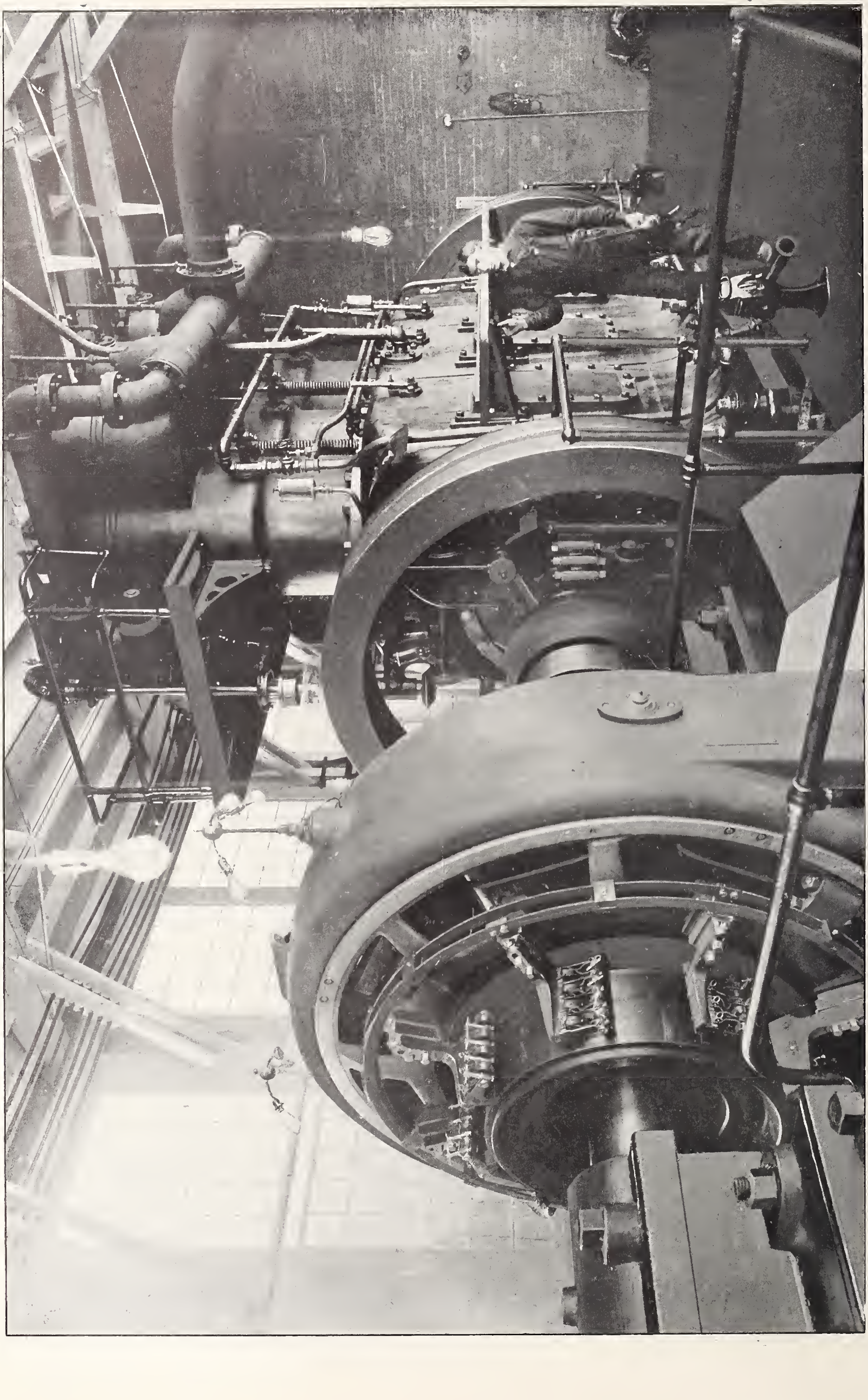
The movement toward direct connections was simultaneous with a great increase of capacity over the then existing machines. The Edison Jumbo was a direct-current constant-potential dynamo of about 1,200 16 candle power incandescent capacity, or about 100 kilowatts in output; small enough, it is true, as compared with our present standards. The Gordon alternator was a revolving-field machine, the field being about eight feet in diameter, revolved by the engine direct (and forming a flywheel for the same) at a speed of from 140 to 180 revolutions per minute, the periodicity being about 45 cycles. Its capacity was about 5,000 incandescent lights, or roughly, 350 kilowatts output. These were very large machines in their day. The Edison Jumbo weighed 25 tons and the Gordon alternator 22 tons. It is interesting to note that the Armington & Sims engines, which drove the later Edison Jumbos, were specially designed to secure relatively high speed, so as to meet, as far as possible, the dynamo conditions. Later on these same high-speed engines were extensively employed in electric stations, belted to dynamos running from 600 to 1,500 revolutions per minute, and employed for incandescent or arc lighting in small units. The example of direct connection gradually spread, and the direct-connected electric plant has at last almost entirely displaced belt-driven machines.

The growth was rather slow, and less rapid in the United States than in Europe. There was, of course, much work to be done in perfecting details, and the substitution of the large direct-connected unit for belt-driven types may have been retarded by the exceedingly rapid development in various electrical fields.

The replacement came about partly on account of the increasing output, not only of the stations, but of the units themselves, up to 5,000 or 6,000 kilowatts each, in some of the large generating stations to-day. As the



ONE OF THE NÜRNBERG GAS ENGINES BUILT BY THE ALLIS-CHALMERS COMPANY, CHICAGO, ILL., IN SIZES FROM 250 TO 6,000 H. P.



A 650-H. P. DIRECT-CONNECTED WESTINGHOUSE GAS ENGINE AND GENERATOR

size of the unit increased, the speed, of necessity, came down to accommodate the heavy reciprocating steam engines employed. This, however, so far as the dynamo was concerned, was only to be accomplished by the use of very massive machines. The dynamo machine, and other electric machines, are essentially high-speed machines, and any straining for low speed must always be paid for in excess of material or diminished efficiency, or both. Nevertheless, the direct-connected, slow-speed machine of sufficiently large capacity has proved itself very satisfactory in practice, and has become almost universal. Still, engineers have not been content, and it seems as if we are on the eve of another decided change.

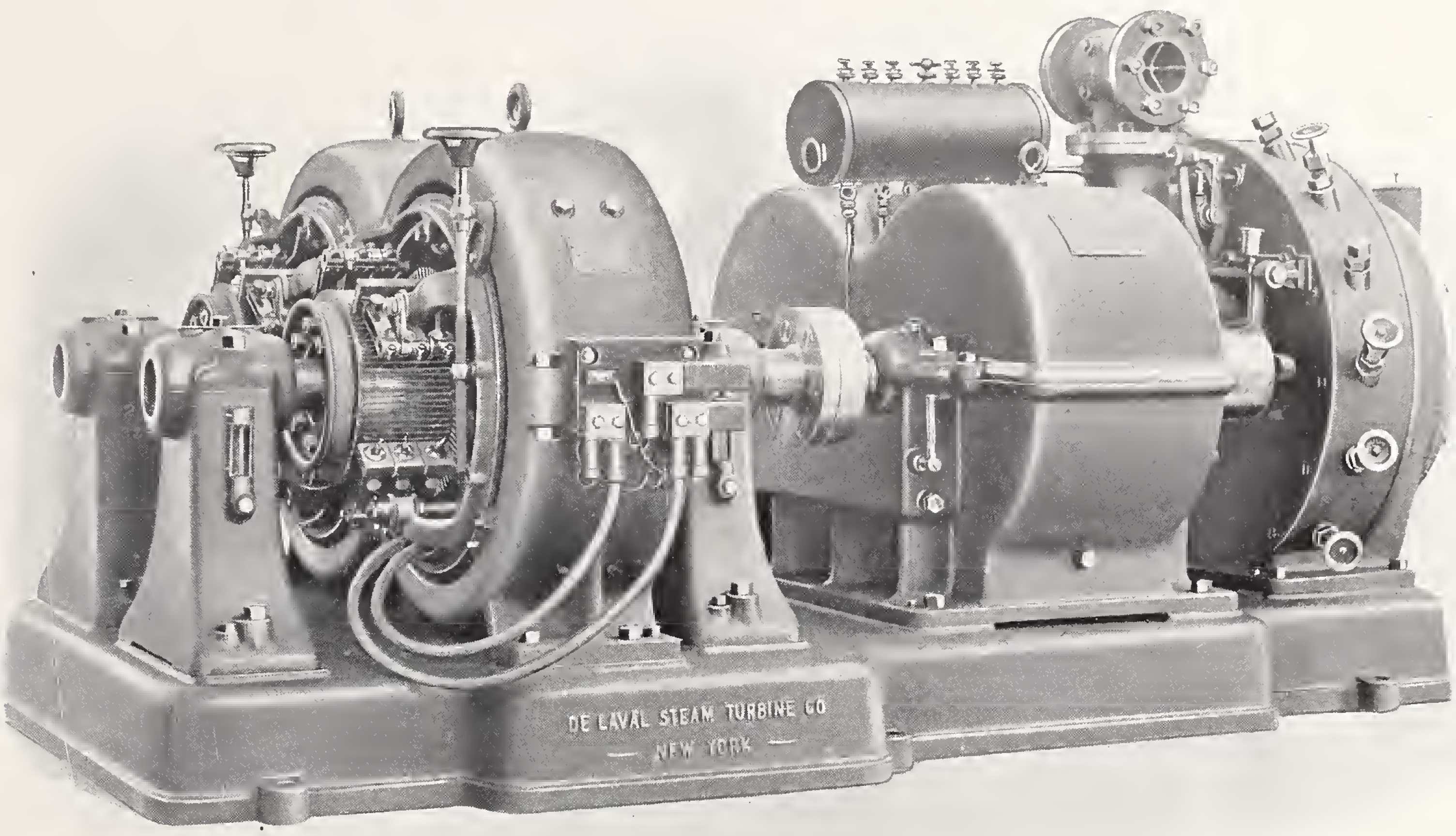
In some cases in cities the vibrations caused by reciprocating engines have, in fact, forced a change in the character of the motive-power machines. Instead of bringing down the dynamo to steam-engine conditions, we now bring the steam engine to dynamo conditions by changing the type of engine employed. In fact, the new problem was to bring down the turbine engine, with the excessive speed required for economy of steam, to such speeds as were within the range of feasible dynamo construction. It is now about 12 to 15 years since the Parsons turbine was applied to drive direct-connected dynamos of small capacity. The earliest of these ran at about 10,000 turns per minute, and really presented the difficulty that the speed was far in excess of reasonable dynamo speeds. The thing had in fact, been overdone. Growth in size of units and perfection of design allowed the speeds to be lowered to about 3,000 turns in moderately sized units, and still lower in the largest units, thus adapting the speed to a proper proportioning of dynamos. The lower limit of speed depends on the size or capacity of the turbine engine, but it will probably not go much below 500 turns per minute, even in the largest units.

In the De Laval turbine the construction is such that reasonable speeds for dynamo work are to be obtained only by a remarkable development of reducing gear. In such a case the plant becomes no longer direct connected. While in the Parsons form of turbine the steam, entering at one end over the whole wheel and passing in succession sets of vanes carried thereby and stationary vanes or guides alternating therewith, progressively expands until it reaches the exhaust end, the expansion in the De Laval takes place in the nozzle, or set of nozzles, the steam being directed against the vanes of a portion of the periphery of the vane-carrying disk. The form of jet or nozzle is flaring toward the wheel, and the conversion of the kinetic energy of the steam into motion in one direction takes place in the expanding nozzle itself, and the fall of temperature and pressure therefore occurs largely before the steam reaches the wheel, which itself revolves in a fairly good vacuum provided by the condenser.

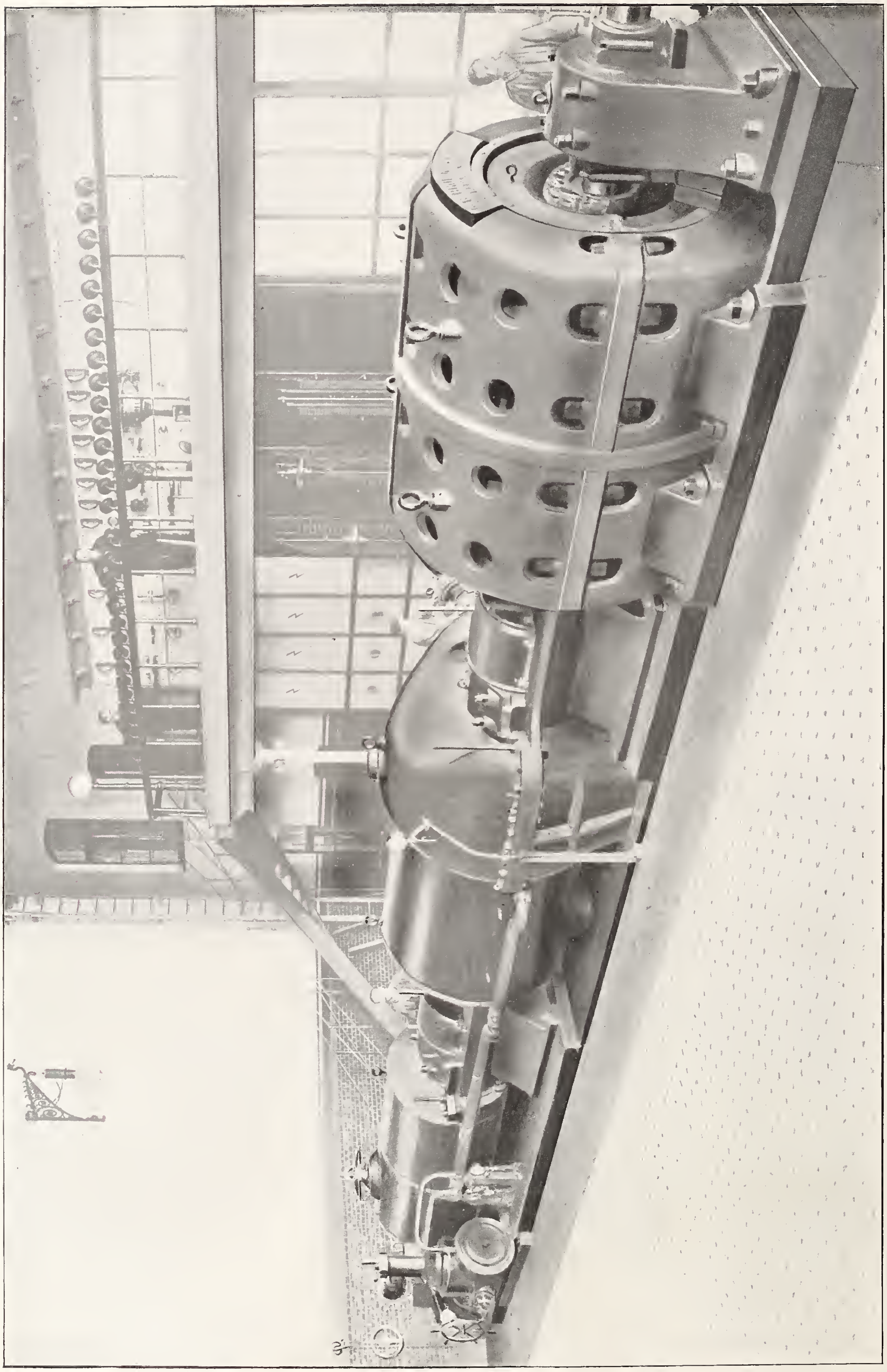
In the lately developed form of turbine, due to Mr. Curtis, the work of the steam is divided into distinct stages, part of the expansion taking place definitely in each stage, and part only of the periphery of the wheels being acted on by the jets or by steam passing the intermediate guides. The action of compounding is somewhat analogous to that in a compound engine, in which the turbine wheels of the successive stages are taken to represent the succession from the high-pressure to the lowest pressure cylinders.

The turbine engine is essentially a machine of which the efficiency depends in large measure upon its exhausting into a vacuum. The condenser is therefore a very important auxiliary.

In the Curtis turbine the ability to secure relatively low speeds is shared



A 300-H. P., 200-K. W. DIRECT-CURRENT TURBINE-DYNAMO SET, MADE BY THE DE LAVAL STEAM TURBINE COMPANY, TRENTON, N. J.



THE 5,000-H. P. TURBO-GENERATOR AT THE FRANKFORT ELECTRICITY WORKS, FRANKFORT-ON-THE-MAIN, GERMANY. BUILT BY MESSRS. BROWN, BOVERI & CO., LTD., BADEN, SWITZERLAND

with the Parsons form, and the ability to govern output by increase or decrease of steam entering the nozzles is shared with the De Laval form. This latter feature is valuable in governing and in meeting overload conditions. The present intention, however, is not to go into the details of turbine construction. It is rather to point out and emphasize the apparent fact that the low-speed direct-connected unit—the huge generating plant of to-day—must probably eventually yield to the much smaller, relatively high speed and less costly turbine-driven plant. While, perhaps, there will be little, if any, gain in steam economy at full load, the turbine has the decided advantage that the efficiency curve holds up for partial loads, even for much below half load, particularly when the governing is accomplished as above indicated. This valuable feature is, as is well known, absent in the compound engine of ordinary type, the efficiency curve falling off very rapidly with decrease of load to a point which soon neutralizes all the advantage of compounding. The turbine is essentially a high-speed rotary engine, an ideal for electric machinery, with simple bearings, constant angular velocity, high light-load efficiency, and light weight. It is particularly adapted to the large units now in use so extensively. The turbine seems destined to play a large part in the future development of the electric power and lighting station.

While it does not promise great gain in steam economy under full load, as compared with the reciprocating types, the average result where load changes are taking place will, doubtless, be that a much better economy is obtained. The gains in original outlay, in space taken up, and in maintenance cost seem to be so considerable as to be decisive as to its adoption.

Looking still further ahead, can we be assured that it is the ultimate step? Laying aside as improbable the direct conversion of the energy of fuel into electric energy, inasmuch as we see no promising signs of its possibility, and considering the fact that the cost of fuel will probably advance steadily as our near-the-surface coal supplies are worked out, it would seem that we must perforce at last turn to those forms of prime movers which have inherent possibilities of developing much higher efficiencies in the use of fuel than are existent in the steam engine. Even at the present day, in certain relatively very small units, the internal combustion engine, such as the gas or oil engine, has shown efficiencies nearly double that of the best steam-engine plant, and the partial load efficiency is also satisfactory. There can also be no question that the internal combustion engine is susceptible of improvement, such that in large units the present attained efficiency will be far surpassed. It seems even probable that an efficiency of heat conversion up to between 40 and 50 per cent. will some day be practicable—a result about three times better than is attained with steam. The engines which would be used would naturally be of large reciprocating type and comparatively slow speed, unless some form of gas turbine be developed—a matter upon which serious doubts may be expressed.

What is meant by a gas turbine is a turbine driven by gas expanding from a chamber in which the gas is burned at high pressure and temperature with the requisite amount of air. Such a machine demands the pumping of the air and gas prior to their combustion. The waste gases are, of course, incapable of condensation in a condenser.

The problems involved in a gas turbine are, then, altogether different from those of a steam turbine engine, and they are necessarily more difficult of solution. In favor of the ordinary gas engine is the fact that all grades of fuel gas may be used with almost equal facility, and even the poor gas, of very low calorific value, such as is sometimes a waste product of blast furnaces in iron smelting, may be used. Coal dust, culm and waste of mines, of low fuel value, may be made to yield gas suitable for feeding gas engines. Liquid fuel, as oil of various grades, is also available, and engines have been run, experimentally at least, by feeding them simply with coal dust itself. The richest fuel, down to the lowest and poorest grade, may therefore be employed directly or indirectly in gas-engine work, and a good efficiency, much exceeding that obtainable with any form of steam engine, is even now obtainable, although the units are not very large. Much remains to be done, however, to render the larger types of gas engines equally available with steam engines, and the day of their rapid introduction is probably still far enough away to cause little need for hesitancy in the adoption of turbine plants for electric stations.

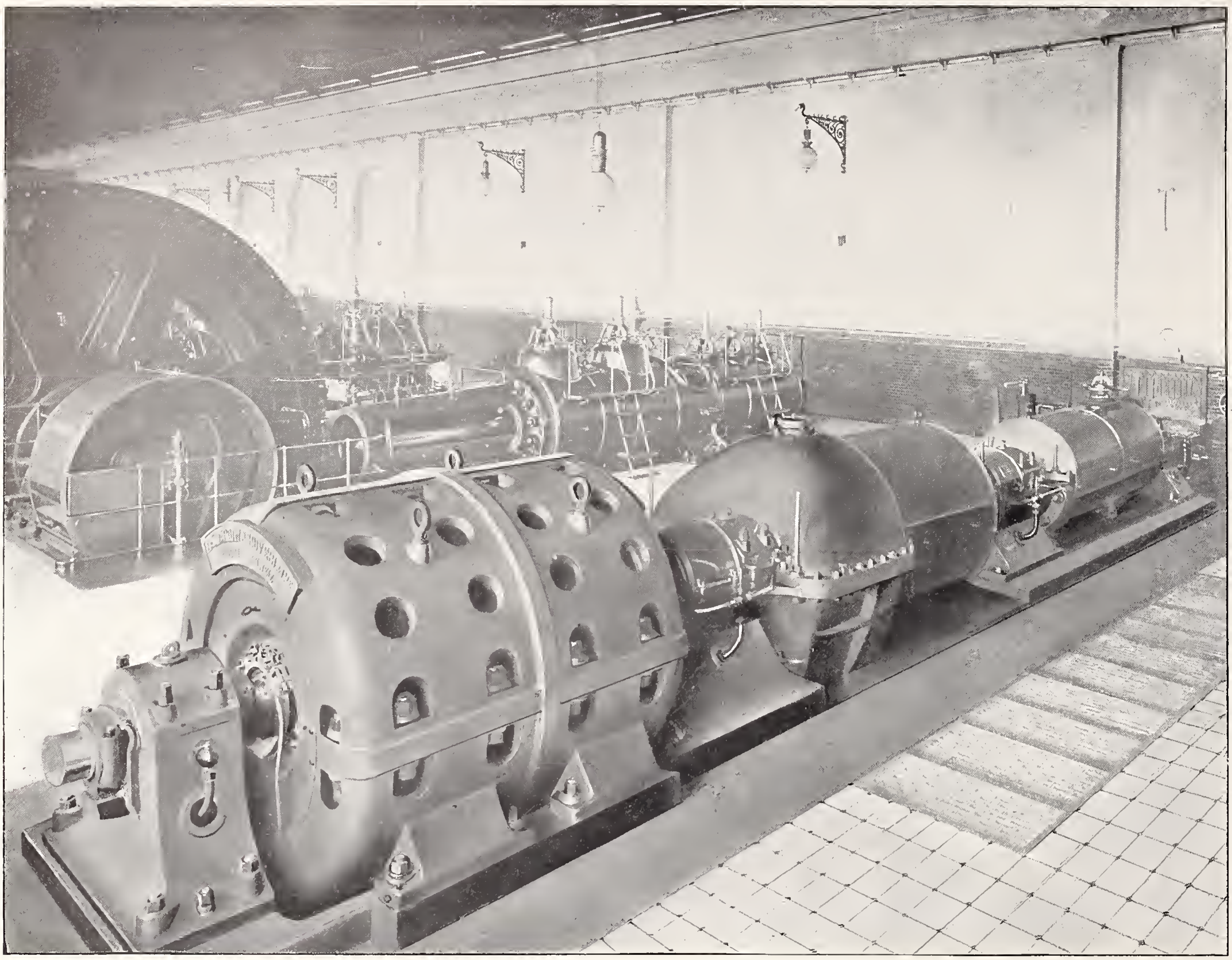
Where soft coal is first converted into gas by a gas producer, useful by-products may be obtained which have sufficient value to warrant their being collected and sold. Moreover, the gas may be continuously produced and stored until needed. These conditions are, of course, well known. An advantage obtained from the gas engine, and one which has been frequently pointed out, is the short time required to get it into work, and the equally quick shutting down of running expense when it is stopped. Provided only the store of fuel is ready to be drawn upon, there is no fuel expense other than expense for fuel during running, the other costs being largely interest on plant. A quickly stopped and started gas-engine plant can take care of load peaks most effectively and efficiently. But if the gas engine should ever become a general source of power, what becomes of our driving? Will it be brought again to belting or some form of gearing up for increase of speed, or will the heavy direct-driven dynamo again be found coupled to gas engines instead of reciprocating steam engines?

It is not probable that large gas engines will be run much faster than steam engines of equal power, so that the queries just propounded will need to be answered by future engineering provided we are right in assuming that the future economical commercial conversion of the energy of fuel into power must come through improvement and increase of size of gas engines. In the considerations above advanced the use of water power is purposely neglected. The amount of water power which can be rendered available with economy is limited, and it is fairly local, in spite of long-distance transmission, while the need of electric generating stations will be more extended and universal as time goes on. The heavily trafficked trunk-line railroads will need them, and the replacement of small powers by electric motors is a future business which has only just begun, according to all present indications.

The 5,000-H. P. Turbo-Alternator at The Frankfort Electricity Works

THE main central station of Frankfort-on-the-Main, Germany, was built in the summer of 1894 and opened in October of the same year. The plant supplies current for a lighting system and also for a power and traction service. At the end of 1901 connections had been made to supply over 14,000 kw. between power and lighting, and to meet this demand a 4,000-5,000 H. P. Brown-Boveri-Parsons turbo-alternator was put down and started in August, 1902.

This new generating unit was made and installed by the firm of Brown, Boveri & Co., Ltd., of Baden, Switzerland, who are also the constructors of the whole of the electrical portion of the plant. Illustrations



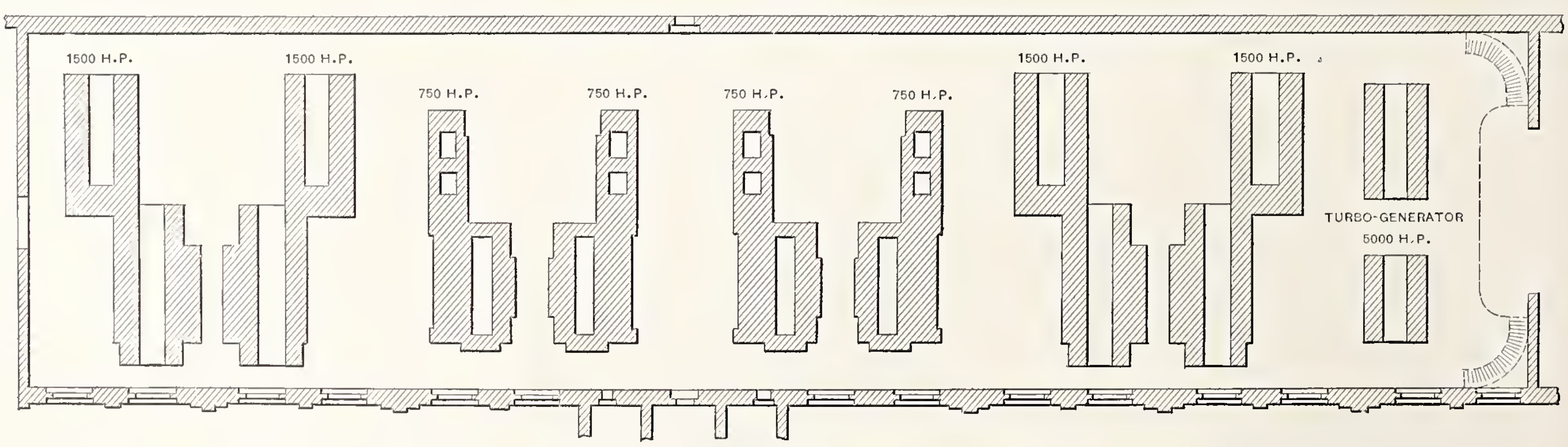
A VIEW OF THE FRANKFORT 5,000-H. P. TURBINE GENERATOR, AND A 1,500-H. P. TANDEM COMPOUND RECIPROCATING ENGINE IN THE SAME STATION

of it are given on page 126 and on the present page. The turbine is designed to run at 1,360 revolutions a minute, with a steam pressure of 13 atmospheres and 300° C. superheat. The single-phase alternator, direct-coupled to the turbine, has an output of 2,600 kw, the tension being 3,000 volts.

It was the intention of the Electricity Supply Company to change the alternator in course of time from single to three-phase with an increase in output, i. e., 3,200 kw, as a three-phase machine. The turbine which runs today as a 4,000-H. P. machine was on this account designed so as to give easily 5,000 H. P. if necessary, and can therefore be considered as a 5,000-H. P. unit.

The total length of the turbo-alternator is about 55 feet, while the width and maximum height are a little over 8 feet.

The pure and simple lines on which this turbine has been designed and the small amount of floor space occu-



PLAN OF THE ENGINE ROOM OF THE FRANKFORT ELECTRICITY WORKS. THE FOUNDATION AREAS OF THE 5,000-H. P. TURBINE GENERATOR AND OF THE EIGHT RECIPROCATING ENGINE GENERATORS, AGGREGATING 9,000-H. P., AFFORD AN INTERESTING COMPARISON

pied by the set as compared with that taken up by an ordinary reciprocating steam engine can be seen at a glance from the illustrations on page 126. In the upper one the space occupied by the 5,000 H. P. turbo-alternator can be compared with that taken up by a 1,500 H. P. reciprocating steam engine installed in the same station. The lower illustration is a plan of the Frankfort Electricity Works, showing the foundations of the machines it contains. This sketch enables one to form a proper idea of the space occupied by the foundations of the 5,000 H. P. steam turbine. Comparing these with the foundations of the steam engines at work in the same station, it is to be noted that in spite of their size, these steam engines have a total output of only 9,000 horse-power.

Group Switches in Large Power Plants

By L. B. STILLWELL, Electrical Director of the Interborough Rapid Transit Company, New York

A Paper Read Before the American Institute of Electrical Engineers

IN a number of large electric generating plants recently designed in America, the feeder circuits are divided into a plurality of groups, and a switch designated a "group-switch" is connected into the circuit between the main bus-bars and each group of feeders. Obviously, no switch should be added to an organization of switch gear already very complicated and expensive, unless its practical usefulness fully justifies its adoption.

Probably no one who knows what engineering means, would affirm without qualification either that he approves the use of group-switches or that he does not approve their use. There are few hard and fast rules in engineering. If such matters as the use or non-use of group-switches could be settled once for all, and for all plants regardless of size, function, or attendant conditions, the purchasing agent would soon succeed the engineer, the pharmacist would take the place of the physician, and the capitalist investing his money in electric power development and use would have no occasion to seek among technical advisers for sound judgment resting upon broad experience and exercised in full knowledge of the existing state of the art, as well as recognition of its general direction and tendency.

Instead of attempting a generalization, therefore, we may consider more profitably the arguments for and against the group-switch in the case of a typical plant, and then glance at some of the modifications of function and circumstance, which in the case of other plants would affect our conclusions.

The group-switch first appeared in the plant of the New York Street Railway Company at Ninety-sixth street, but as the writer had nothing whatever to do with the design of that plant, he selects for consideration the plant of the Manhattan Railway Company. In this plant two complete sets of main bus-bars are used. Switches are provided by means of which each of these sets may be divided into two independent sets of bus-bars to each of which four alternators and four groups of feeders may be connected. Eight group-switches are provided, through each of which current is supplied to a set of auxiliary bus-bars, to which in turn the individual feeders are connected through their respective switches. One of the eight feeder-groups is used to supply power to auxiliaries in the power house. The other seven groups supply power, respectively, to the seven sub-stations which receive power from this central source. All switches in the high-pressure alternating-current circuits are of the motor-operated oil type.

The arguments in favor of the group-switch as used in the plant of Manhattan Railway Company are:

1.—It affords an additional means of opening a feeder-switch that fails to open its circuit, when operated for that purpose. The advantages of the group-switch in respect to this function to-day appear materially less than they did five years ago, for the reason that the power-operated oil-switch within the period named has demonstrated a high degree of reliability. However, it cannot be assumed that the feeder-switch is invariably reliable, and, therefore, judgment of the weight of the argument in favor of the group-switch, based upon its use as a reserve for the feeder-switch, becomes a question of judgment of the chances of failure of the feeder-switch on the one hand and the seriousness of total interruption of power supply on the other.

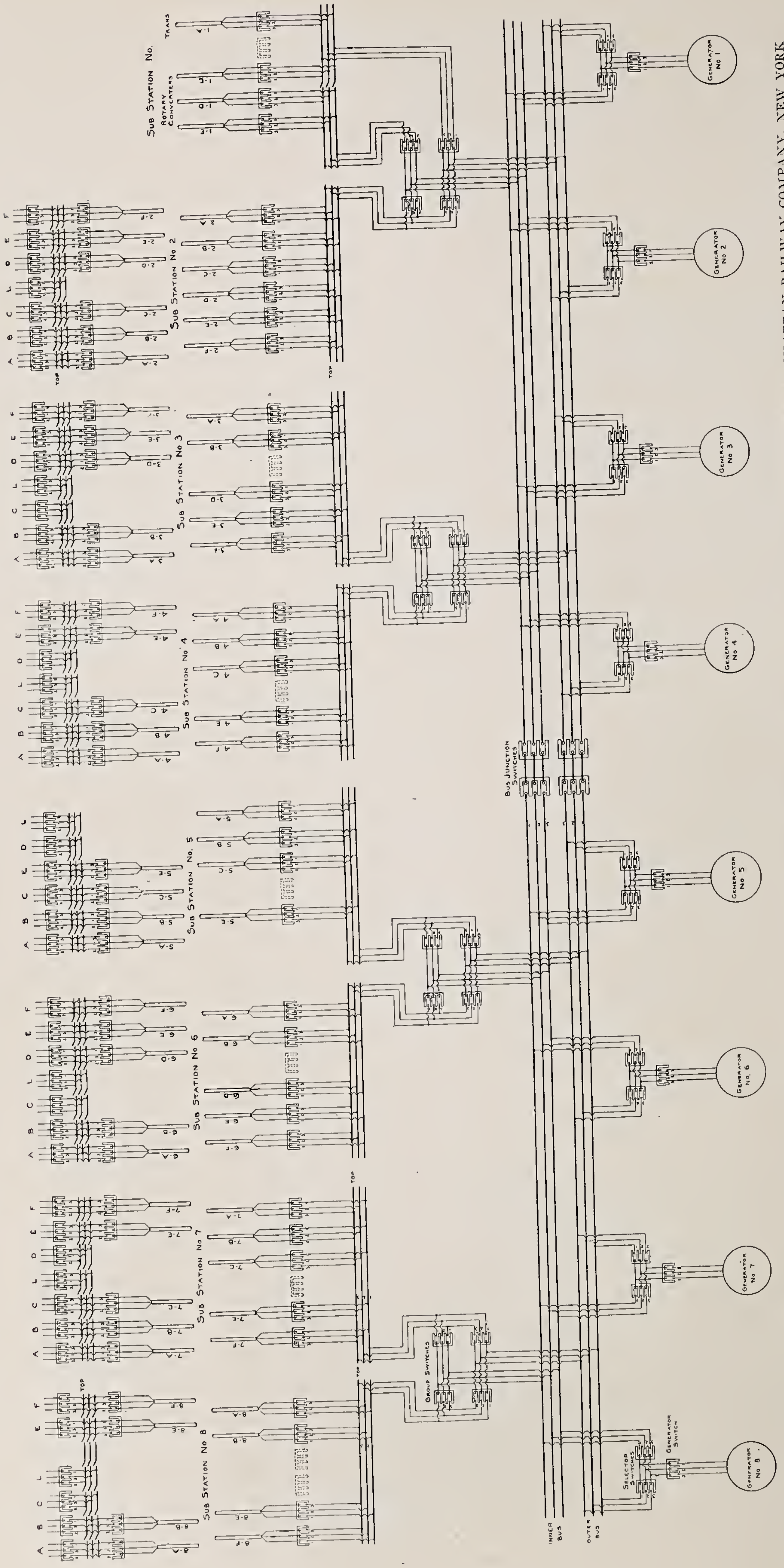
2.—It affords means of reducing aggregate load upon the power house in case of necessity more rapidly and otherwise less objectionably than the usual method of cutting off individual feeders. It will sometimes happen in the operation of a power plant that it becomes necessary suddenly to shut down one of the generating units. If the load carried at the time be such that the shutting down of the generator implies reduction of the external load, this can be accomplished most conveniently by operating one of two group-switches.

3.—Where duplicate main bus-bars are used, it facilitates transfer of load from one set to the other, in case it becomes necessary suddenly in operation to make such transfer. As bus-bars and connections are now installed in our best plants, this necessity does not arise frequently; nevertheless, it is liable to occur, and obviously half a dozen group switches may be used to affect the transfer in much less time than would be required were five or six times that number of individual feeder-switches used.

4.—The grouping of the external feeder-circuits in group units bearing a simple fixed relation to the generator units establishes a symmetry and proportion most useful to the operator, particularly in times of emergency. In the case of the plant under consideration, at times of full load, the power passing through each group-switch is substantially equal to the output of one generating unit. This relation, of course, does not exist under partial loads, but under such loads it is not difficult usually to keep in service generating capacity exceeding the load by a margin sufficient to make it possible to shut down one generator without cutting off feeders; and in cases where this margin of capacity is not kept in service it is, nevertheless, a more speedy and certain operation to cut off the necessary number of groups of feeders than it would be to cut off a proportionate number of individual feeders.

The arguments against the group-switch are:—

1.—It introduces additional apparatus and, therefore, in itself increases the risk of interruption due to failure in switch insulation, etc. The successful operation of many plants, particularly in America, has been interfered with by the introduction of too much switch gear and too many safety devices, automatic and other, these additions in themselves being responsible in some cases for more trouble than they prevent; and it is to be noted that the group-switch implies the auxiliary bus-bar. Here, again, it is impossible to dogmatize, for as the result of addi-



BUS-BARS, OIL SWITCHES AND ALTERNATING-CURRENT FEEDERS OF THE SEVENTY-FOURTH STREET POWER STATION AND SUB-STATIONS OF THE MANHATTAN RAILWAY COMPANY, NEW YORK

tional experience, the judgment of to-day may be reversed five years from now. As an expression of personal opinion, however, I may say that if the group-switch and the auxiliary bus-bars be reasonably well insulated and installed, the interruptions originating in this additional apparatus should be almost negligible in the case of such a plant as that which we are considering.

2.—The group-switch and its bus-bars imply, of course, an increase of cost of the plant. In case of the Manhattan plant this increase is about 10 per cent. of the cost of the switch gear and measuring apparatus, and about four-tenths of 1 per cent. of the cost of the plant. To put it another way, the cost of the group-switches and bus-bars for the plant approximates $20,000, and the annual cost, assuming this to be 10 per cent. of the investment cost, is $2,000, which is about two-tenths of 1 per cent. of the annual cost of operating the entire plant, including sub-stations.

In the plants in which the feeder unit equals or exceeds the dynamo unit of power, the group-switch, of course, disappears. In this case, however, it may still be advisable to use two feeder-switches in series in order to avoid the necessity of shutting down the entire plant in case of the failure of a single feeder-switch.

Obviously, also, there is no reason for attempting to use group-switches in cases where the total number of feeders is small.

For plants comparable in magnitude to the plant of the Manhattan Railway Company, using a very considerable number of feeders, the group-switch is important and its use generally advisable.

Doherty Gold Medal Competition

A GOLD medal will be given by Henry L. Doherty, past-president of the National Electric Light Association, for the best paper, presented at the forthcoming convention of the association, on underground construction for either alternating or direct-current plants or a combination of both, the selection of the best paper to be made by a suitable committee to be appointed by the president of the association.

The object of the award is to obtain for this branch of construction work more consideration than it has heretofore received. What is desired is a paper so complete and detailed that it will enable any central-station man who is obliged to put his wires underground, to undertake the work simply through the guidance of the paper.

Competitors for the medal will not be confined to members of the association. Mr. Doherty's generous offer was made at the Cincinnati convention and was accepted by the association, under the condition that not less than five papers be contributed on the subject. Papers must be received at the office of the association, 136 Liberty street, New York, not later than April 21, three copies of each paper being requested.

Wireless Telegraphy in the Revenue Service

ELECTRICITY will soon be made use of in rather a novel manner by the United States revenue officers, according to daily newspaper dispatches. The smuggling of Chinese and opium into this country, across the Straits of Fuca, has long been a profitable, though ofttimes hazardous, industry among certain not overly conscientious citizens of the State of Oregon. Small sloops, carrying cargoes of contraband Celestials and opium, race across the Straits from Victorian and British Columbian ports, and, if danger threatens, take refuge among the numerous islands which abound in the vicinity. It would be impossible, without an extensive fleet of revenue cutters, to thoroughly patrol these waters, and the authorities have had perforce to look further afield for a successful means of coping with the difficulty. Wireless telegraphy has filled the blank, and the revenue cutter "Grant" will be fitted with apparatus which will enable her to maintain constant communication with the land station at Port Townsend. Numerous other stations are to be installed at suitable points, and it is anticipated that the system, when completed, will enable the "Grant" or other cutters to proceed at once to the spot where a suspicious craft has been sighted.

The Canadian boundary between Lake of the Woods and Point Roberts has long been another field of operations for introducing John Chinaman into this country, the wildness and remoteness of that section making a thorough patrol of it by revenue officers out of the question. However, a resolution recently introduced before the House of Representatives by Congressman Dixon offers a solution of the problem, which seems as practicable as it seems simple. It has for its object the construction of a barb-wire fence between Lake of the Woods and Point Roberts, equipped with telegraph, telephone or other electric apparatus to convey warning to inspectors and others charged with the execution of the exclusion and tariff laws. When one considers the Chinaman's flowing costume the true inwardness of using barb wire in the construction of this, as it may not be inaptly termed, Chinese wall, will at once be apparent.

The Berlin Type-Printing Telegraph Station

THE type-printing telegraph service recently installed in Berlin is intended to afford a useful complement to existing telegraph and telephone systems. In telephonic communication there is a possibility of mistaking the spoken words, and the absence of an acknowledgment in writing of the transmissions, such as is frequently required for business purposes; on the other hand, conversation may be overheard by a third person.

The central station just opened in Berlin is intended to insure mutual communication between any two subscribers to the new system, as well as the simultaneous transmission of special dispatches, such as exchange telegrams, from one sending station to any desired number of subscribers. The apparatus is also likely to be useful in the case of the person rung up being absent, as the telegram, being printed on his receiving apparatus, will be found by him on his return.

The type-wheel is provided on its periphery with two circles of types, corresponding with the letters and the figures and signs of punctuation, respectively, the type-wheel being adjusted for either of the circles by means of a shift key. The printing takes place simultaneously in both the sending and receiving apparatus, no matter whether anyone is operating the latter or not.

The working of the newly opened central station is quite similar to that of a telephone station. There is a switchboard for 100 subscribers. As soon as a subscriber strikes the calling key of his apparatus the operator in charge of the switchboard at the central station is advised by the dropping of the indicator of the subscriber in question and the ringing of a bell. The operator then puts himself in communication with the caller, asks him for the desired connection and connects the two subscribers, so that their respective apparatus is immediately ready for mutual communication.

Some English Portable Electric Drilling Machines

An interesting form of portable electric drilling machine, brought out in England by Messrs. Campbell & Isherwood, of Bootle, near Liverpool, is shown in Figs. 1 to 5 of the illustrations on this page and on pages 43 and 44.

Figs. 1 and 2 show the drill, or, more strictly speaking, the motor part of the outfit, mounted on a truck so as to permit ready moving about from place to place as needed, while Figs. 4 and 5 on page 44 show a machine arranged for being raised in the air and slung in convenient position for drilling without the use of stay-ropes, steadying gear, or platform. With this particular type of machine, there are no flexible or telescopic shafts, or knuckle joints for transmitting the power from the motor to the drill. The drive is practically direct. It is possible to start and stop the drill instantly without removing the hand from the drill-head, and the whole machine can be easily managed by one man.

The carriage for the motor is two-handled, so that it can be wheeled like a truck, or, perhaps, more in the manner of a wheelbarrow with two small front wheels. When the handles are released, the two short legs, corresponding to those of a wheelbarrow, hold the truck in place so that it cannot move about readily, as a four-wheeled truck would do. When in its carriage the motor rests on trunnions. On the top of the motor is a bracket carrying a hollow shaft; on one end of this shaft there is a spur-wheel which is driven from a pinion on the armature shaft. Through the hollow shaft there slides a long internal shaft, the end of which is connected with the drill-head. The hollow shaft has a key on the inside, and this engages in a slot which runs nearly the whole length of the long internal shaft. The motion is thus conveyed from the motor through the hollow shaft to the long sliding shaft which naturally can be carried to the work to the limit of its length, or can be brought back so as to bring the drill-head close to the motor.

The drill-head itself consists of two pairs of bevel-gear wheels, there being four wheels in all, as shown in Fig. 3. The hand-wheel at the top in this illustration is for feeding the drill spindle down, when it is held in the clamp, as shown in Fig. 4. With this arrangement the drill may be turned through a complete circle in the plane at right angles to the long shaft, and through almost a complete circle in the same plane as the shaft. In place of the bevel-gearing a universal worm-gear drill-head can be fitted when tapping has to be done, a slower and more positive motion then being required.

The capacity of the machine is to drill holes in steel up to 1½ inches in diameter; but still larger machines are being made which will drill holes 3 inches in diameter. The 1½-inch-hole machine is of 1½ horse-power, whilst the 3-inch hole machine will be of 3 horse-power. The motors can be arranged for any voltage of continuous current from 50 to 500. It is calculated that a 1½-brake horse-power drill will take approximately 1300 watts per hour. The weight of the motor is 240 pounds, the carriage weighs 138 pounds, the shaft 24 pounds, and the drill-head 44 pounds. A switch is placed close to the drill-head, so as to be within reach of the operator to stop and start the machine immediately. The large range of this extremely handy portable drill will be at once apparent.

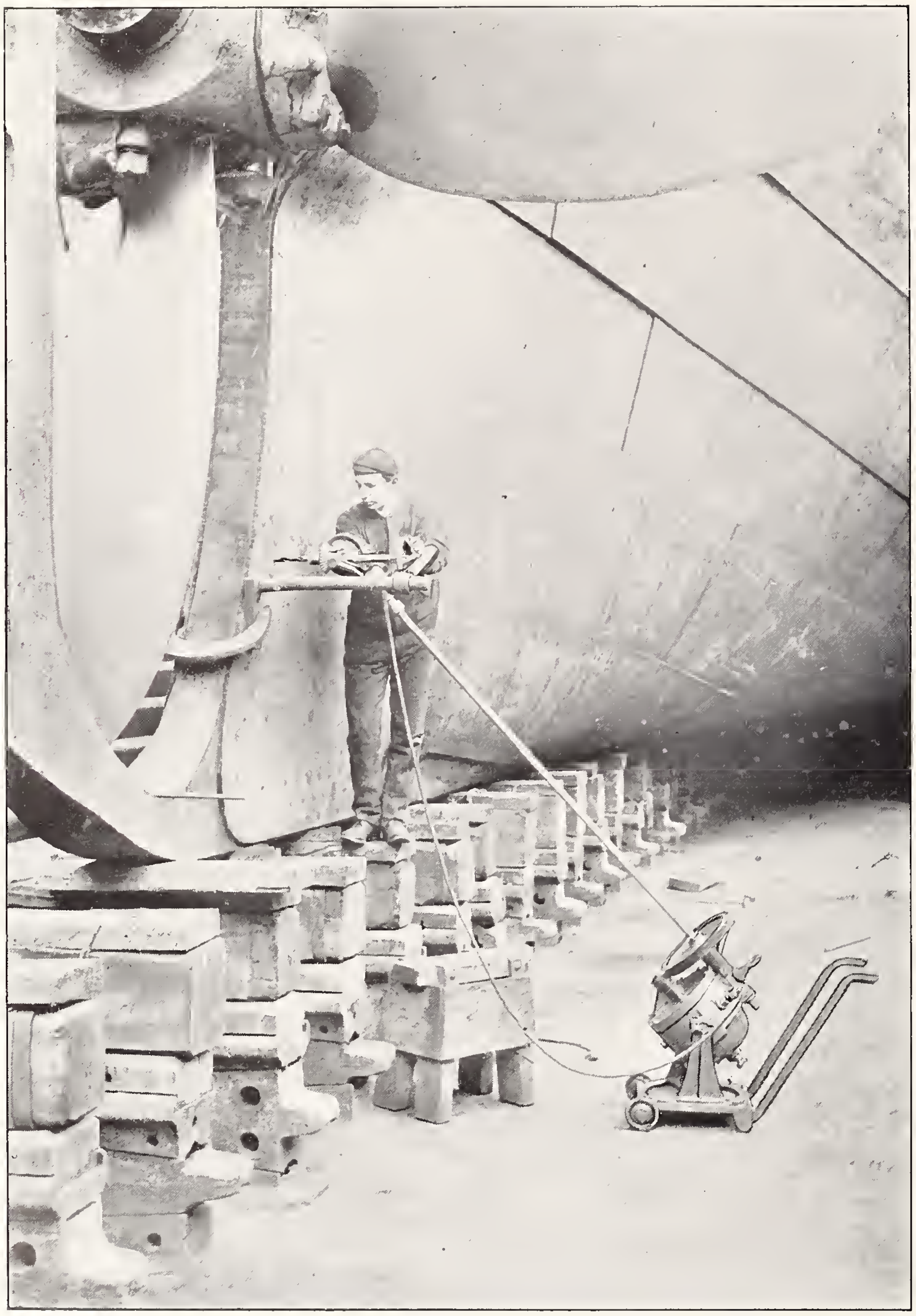


FIG. 1.—A PORTABLE ELECTRIC DRILL, MADE BY MESSRS. CAMPBELL & ISHERWOOD, LIVERPOOL, ENGLAND

An investigation has recently been made, by a German engineer, of the water power available from the rivers on the northern slopes of the Alps. The total power of the streams in this region is estimated at 6,000,000 horse-power, of which about one-half could be utilized for economic purposes. Only about 10 per cent. of the available power is employed at present.

Automobile Roads of the Future

AN interesting presentation of the commercial possibilities in the building of special tracks for automobile roads was given in a recent number of "The Car," by Comys Beaumont. The writer maintains that this full exploration of mechanical traction would show financial results sufficient to convince the most energetic opponent to automobilism that it is a force destined to have far-reaching results. He proposes for England a number of car ways covering the entire country.

Motor roads would be expensive to build, but the outlay, he claims, required by the most extravagant methods of building would not amount to a fraction of what a railway costs to lay, leaving the rolling stock out of the question altogether, because not only would such roads be infinitely cheaper to build per mile than railroads, but since termini and near approaches to towns or cities are rendered unnecessary there is no need to expend vast sums in purchasing property in the heart of valuable districts, which is always a great capital outlay necessary in railway construction.

A motor car can leave the road at either terminus and take ordinary roads leading to any point in a city or its suburbs, and at almost any point along the way a car can, of course, turn off and travel on the regular highways. The main object of a car way being to take absolutely the shortest and most direct route between two given points, no deviation whatever is made to include some town of importance. A railroad track laid on this principle would be manifestly absurd, but in a car way it matters little. A car bound from London to Coventry would leave the way at the most convenient junction for the latter city (two or three miles, more or less, not signifying), while if the route were to twist and contort itself to include all important areas it would lose its effectiveness; for to enable the motor car to prove its superiority (convenience and speed united), it requires every assistance toward the consummation of both, which is exactly what the function of a perfectly straight car way will be to provide.

Mr. Beaumont claims the laying of such ways is not only practical, but should prove an excellent and paying investment if adequately capitalized. Nor is the capital required so great as might be supposed. He proposes a breadth of twenty-five feet, to permit of four cars abreast, leaving plenty of room between them.

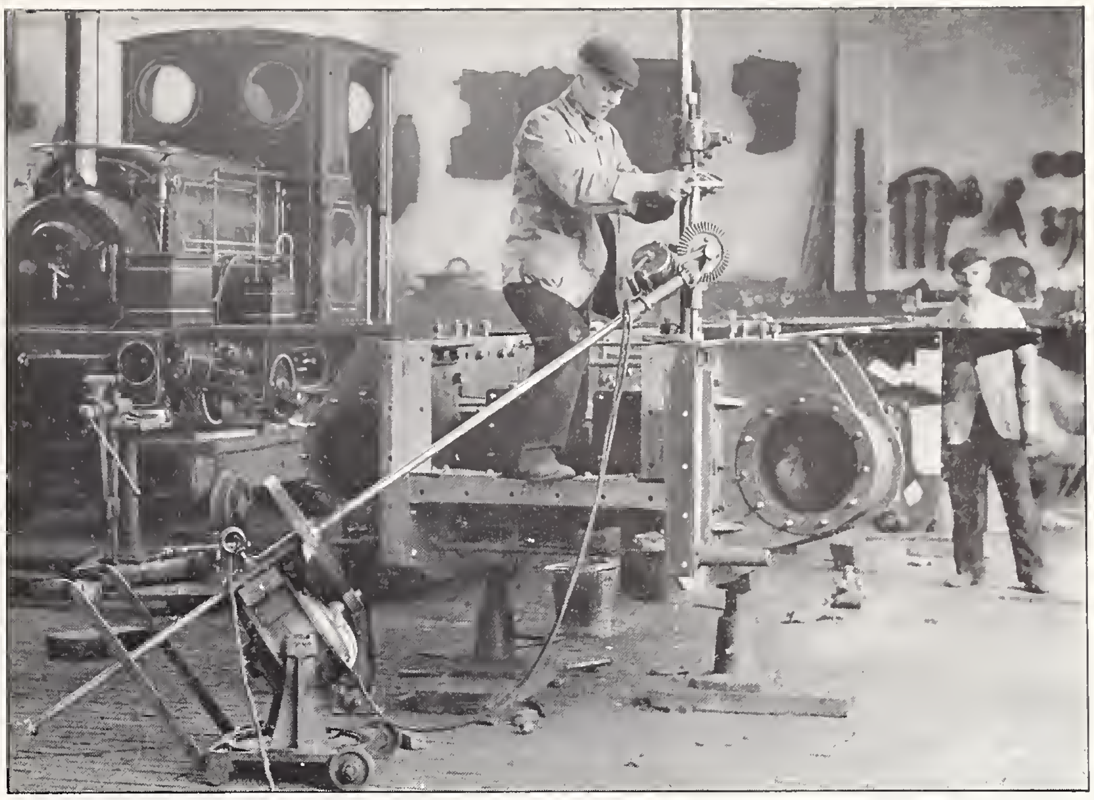


FIG. 2.—THE SAME KIND OF DRILL ON LOCOMOTIVE WORK

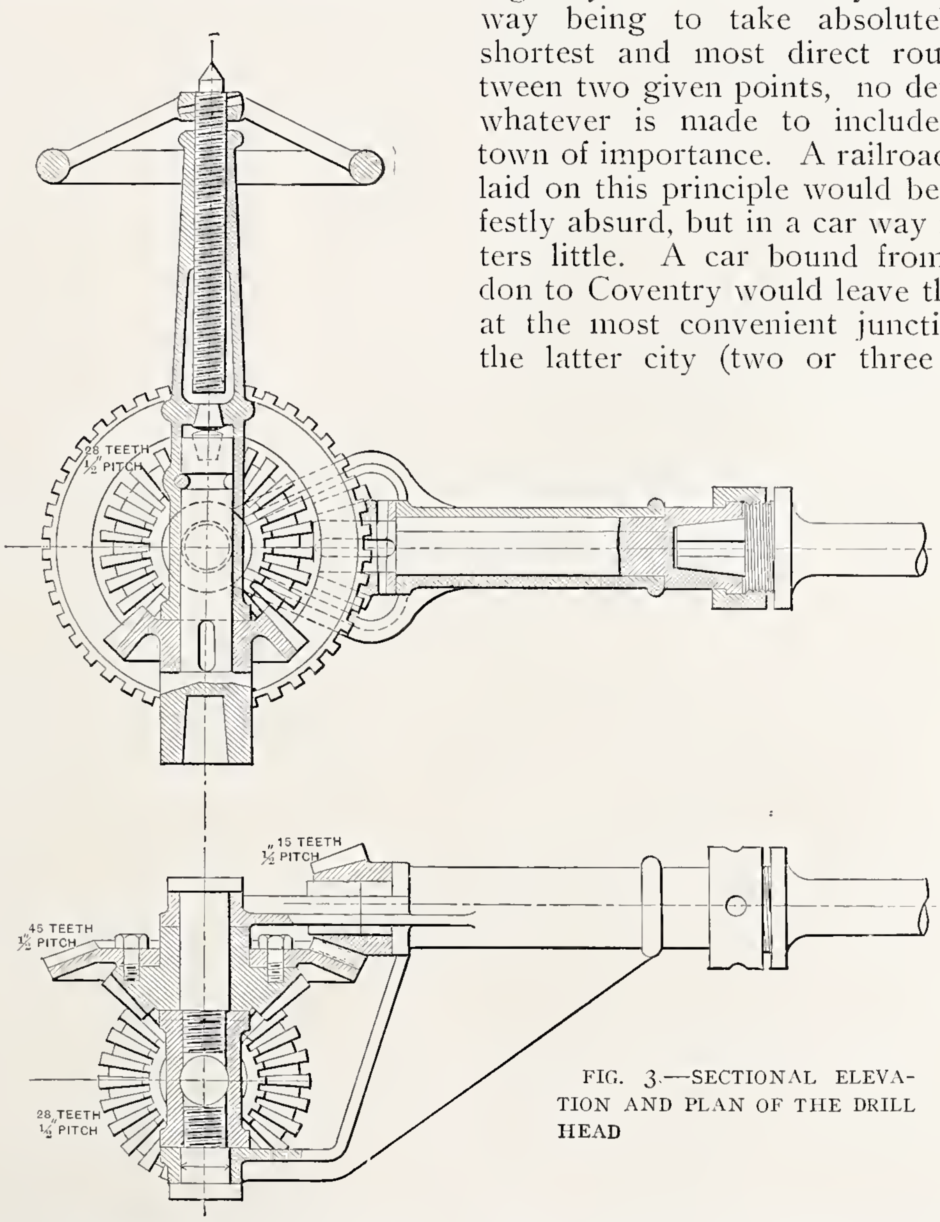


FIG. 3.—SECTIONAL ELEVATION AND PLAN OF THE DRILL HEAD

From Naples to the Summit of Vesuvius by Electricity

A NEW line of electric railway up Vesuvius, from Resina to the foot of the cone, to connect with the old funicular railway to the crater, has been completed by Messrs. Thos. Cook & Sons, the noted tourist agency. The starting point of the new railway is Pugliano, which, except for a very small stretch not yet completed, is in itself connected with Naples by electric trams, so that when this short extension is finished, it will be possible to travel by electric power from the heart of Naples to the summit of Vesuvius. The length of the new railway, exclusive of the line up the cone, is nearly 5 miles, and is divided into three sections. The first and third sections are both adhesion lines. The maximum incline on both these sections is only 8 per cent. The second section is a rack railway, with a maximum incline of 25 per cent.

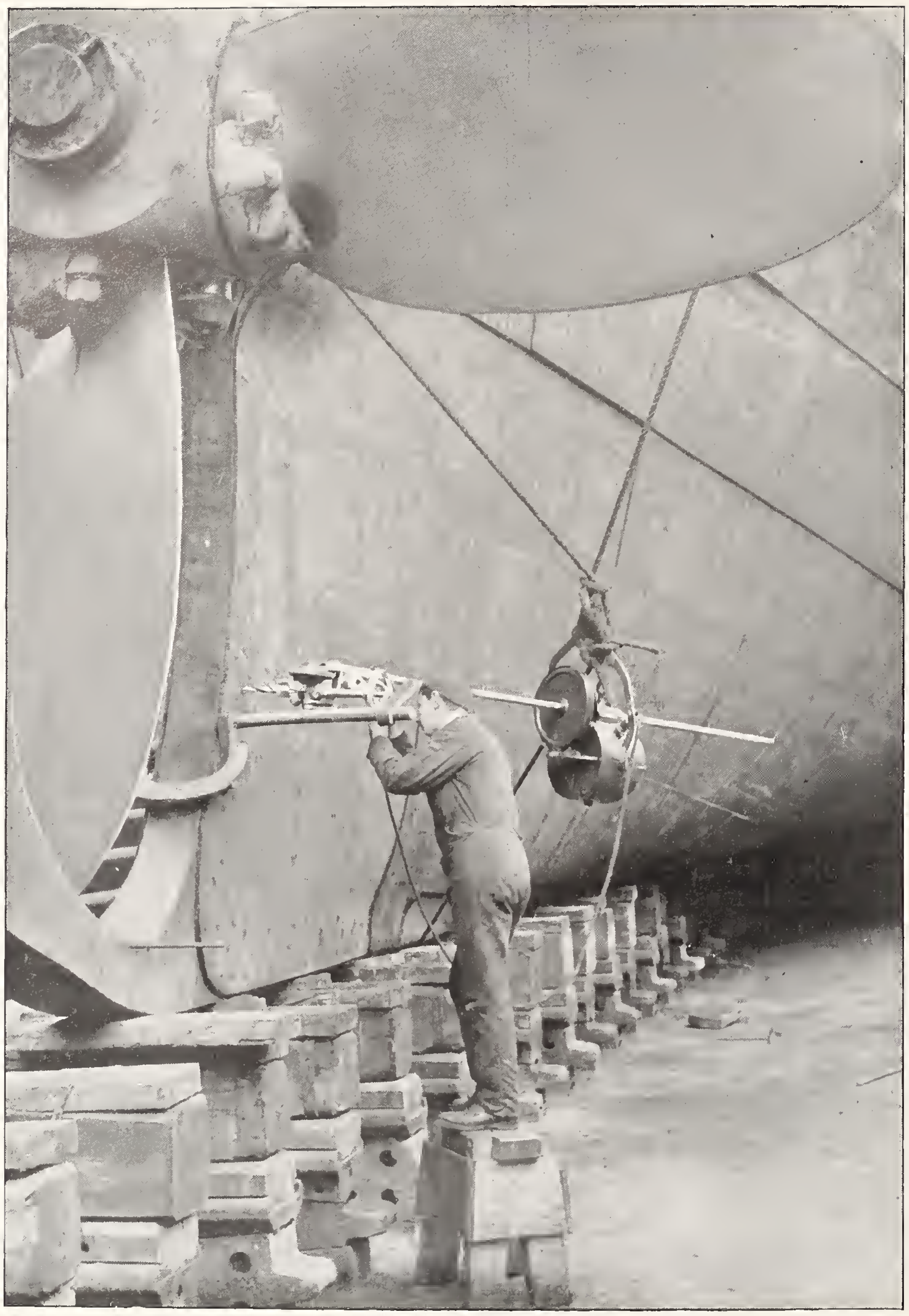


FIG. 4.—A SUSPENDED DRILL WORKING ON SHIP PLATES. SEE PAGE 130

Telegraph Construction in the African Jungle

A DIFFICULT piece of telegraph and telephone construction work was recently completed in the Belgian Congo Settlements. According to the London "Electrical Engineer," the line is 750 miles long, the first section undertaken being that from Boma to Matadi, a distance of 18 miles. This length took no less than eight months to construct. White labor was precluded by the climate, and the greater portion of the work was done by natives under the direction of Europeans.

The work was complicated by several difficult streams which had to be crossed. The crossing at Underhill was effected by means of two steel pylons, 50 feet high and 2620 feet apart, and placed respectively 237 feet and 206 feet above the high-water level. The construction of the line from Léopoldville to Equateur was also very difficult. Surveys were particularly dangerous, and the zone was unhealthy. Advantage was taken as far as possible of the forest trees in fixing supports for the line. The crossing of the Kasai River was probably the most difficult piece of work, as it was necessary to keep the stream clear for the steamer traffic. Advantage was taken of a rocky island in the river, and the crossing was made in two spans, one of 1472 feet and the other of 2198 feet, the supports being three iron pylons. Much trouble was experienced in getting the four conductors in place, but this was eventually accomplished with a steam tug.

The maintenance of the line is expected to give considerable difficulty, for although the posts are either of iron or living trees, and, therefore, proof against the attacks of white ants, elephants abound, and storms occasion great interference by throwing down trees across the line. Atmospheric discharges are also troublesome. Birds make their nests on the wire, wasps nest in the insulators, and spiders cover the poles with web, collecting a litter of leaves and twigs. The line is used both for telephone and telegraph service, and the stations are protected by local garrisons.

The utilization of what formerly were considered waste products, says "Cassier's Magazine," and the resurrection of materials from a used-up state to a new condition of serviceableness have in recent times been developed to such a degree of completeness that we are scarcely prepared to admit that anything is ever irrecoverably lost. In this respect we believe in the conservation of materials just as we have long been taught to believe in the law of conservation of energy. From a purely practical point of view, however, some things certainly may be so completely lost to further use that their loss may well be considered absolute, and one of these is the metal lost in the wear of railway rolling stock brasses. For the speculator in copper values, the promoter of a copper "corner," to use the broker's cant, the copper which has gone into railway brasses need have no terrors. It is not likely ever to be available again in full measure. It is dissipated so completely, in part at least, that its practical recovery is not likely to receive much serious consideration. From the best available deduction on the subject it appears that 5 per cent. of the annual copper production of the world disappears in this way every year.

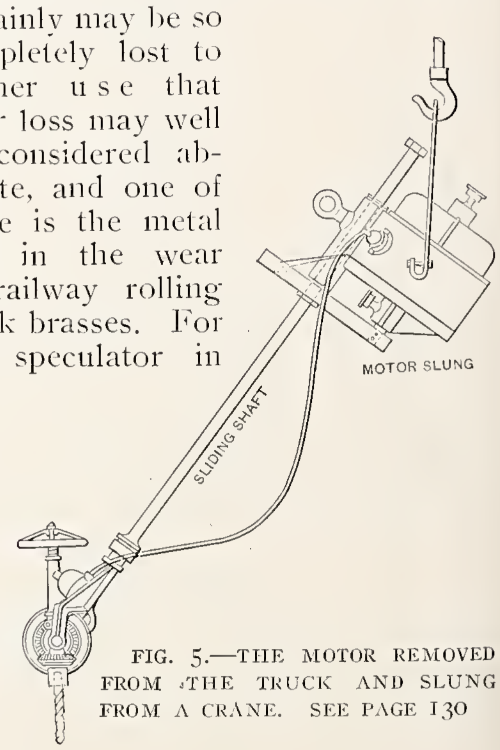


FIG. 5.—THE MOTOR REMOVED FROM THE TRUCK AND SLUNG FROM A CRANE. SEE PAGE 130

Voltage and Losses on Transmission Lines

By ALTON D. ADAMS

THE voltage on a transmission line may be anything up to at least 60,000, and the weight of conductors varies inversely with the square of the figures selected, the loss being constant. Whatever the total line pressure, the weight of conductors varies inversely with the percentage of loss therein. These rules hold good regardless of the amount of power involved, or the length of the transmission.

The case of maximum loss and minimum weight of conductors is that in which all of the transmitted energy is expended in heating the line wires. Such a case would never occur in practice because the object of power transmission is to perform some useful work.

Minimum possible loss is theoretically zero, and the corresponding weight of conductors is infinite, but these conditions obviously cannot be attained in practice. Between these extremes of minimum and of infinite weights of conductors comes every practical transmission with a line loss greater than zero and less than 100 per cent.

To determine the weight and allowable cost of conductors the cost or value of the energy that will be annually lost in them enters as one of the factors. At this point the distinction between the percentage of power lost at maximum load and the percentage of total energy lost should come into view.

Line loss ordinarily refers to the percentage of total power consumed in the conductors at maximum load. This percentage would correspond with that of total energy lost, if the line current and voltage were constant during all periods of operation, but this is far from the case.

A system of transmission may operate with either constant volts or constant amperes on the line conductors, but in a practical case constancy of both these factors is seldom or never to be had. This is because the product of the line volts and amperes represents accurately in a continuous-current system, and approximately in an alternating-current system, the rate of energy, that is, the amount of power transmission. In an actual transmission system, the load, that is, the demand for power, is subject to more or less variation at different times of the day, and the line volts or amperes, or both, must vary with it.

If the transmission system is devoted to the operation of one or more factories the required power may not vary more than 25 per cent. during the hours of daily use, but if a system of general electrical supply is to be operated, the maximum load will usually be somewhere between twice and four times as great as the average load for each 24 hours. Such fluctuating loads imply corresponding changes in the volts or amperes of the transmission line.

A comparatively small number of rather long transmissions is carried out with continuous, constant current, and in such systems the line voltage varies directly with the load. As the loss of power in an electrical conductor depends entirely on its ohms of resistance, which are constant at any given temperature, and on the amperes of current passing through it, the line loss in a constant-current system does not change during the period of operation, no matter how great may be its changes of load. For this reason the percentage of power loss in the line at maximum load is much smaller than the percentage of energy loss for an entire day, unless the load is unusually constant.

If, for example, the constant-current transmission line is designed to convert into heat 5 per cent. of the maximum amount of energy that will be delivered to it per second, that is, to lose 5 per cent. of its power at maximum load, then, when the power which the line receives drops to one-half of its maximum, the percentage of loss will rise to 10, because $0.05 \div 0.5 = 0.1$. So again, when the power sent through the line falls to one quarter of the full amount, the line loss will rise to $0.05 \div 0.25 = 0.2$, or 20 per cent.

From these facts it is clear that a fair all-day efficiency for a constant-current-transmission line can only be obtained in conjunction with a high efficiency at maximum load, if widely varying loads are to be operated. It does not necessarily follow from these facts as to losses in constant-current lines that such losses should always be small at maximum loads, for in constant-current, as in constant-pressure lines, the maximum loss is usually the most important, especially in transmissions of water power, and if a large loss may be permitted at full load, a still greater percentage of loss at partial loads may not imply bad engineering.

In a large percentage of electric water power plants some water goes over the dam during those hours of the day when loads are light, the storage capacity above the dam not being sufficient to hold all of the surplus water during most seasons of the year. If, therefore, the line loss in a constant-current transmission, where all of the daily flow of water cannot be used, is not great enough to reduce the maximum load that would otherwise be carried, then the fact that the percentage of line loss at small loads is still larger is not very important.

Obviously it makes little difference whether water goes over a dam, or through wheels to make up for a loss in the line. In a case where all the water can be stored during small loads and used during heavy loads, it is clearly desirable to keep the loss in a constant-current line down to a rather low figure, say not more than 5 per cent., at maximum load.

Much the greater number of electrical transmissions is carried out with nearly constant line voltage, either alternating or direct, and the line current in such cases varies directly with the power transmitted, except as to certain results of inductance on alternating lines. As line resistance is constant, save for slight variations due to temperature, the rate of energy loss on a constant-pressure line varies with the square of the number of amperes flowing, and the percentage of loss with any load varies directly as the number of amperes.

These relations between line losses and the amperes carried follow from the law that the power, or rate of work, is represented by the product of the number of volts by the number of amperes, and the law that the power actually lost in the line is represented by the product of the number of ohms of line resistance and the square of the number of amperes flowing in it. In each of these cases the power delivered to the line is, of course, in watts, each of which is 1/746 of a horse-power.

Applying these laws, it appears that if the loss on a certain constant-pressure transmission line is 10 per cent. of the power delivered to it at full load, then, when the power, and consequently the amperes, on the line is reduced one-half, the watts lost in the line as heat will be $(\frac{1}{2})^2 = \frac{1}{4}$ of the watts lost at full load, because the number of amperes flowing has been divided by 2.

But the amount of power delivered to the line at full load having been reduced by 50 per cent., while the power lost on the line dropped to one-fourth of 10 per cent., or to 2.5 per cent. of the full line load, it follows that the power lost on the line at half load is represented by $.025 \div 0.5 = 0.05$, or 5 per cent. of the power then delivered to it.

This rise in the efficiency of a constant-pressure transmission line as the power delivered to it decreases, together with the fact that maximum loads on such lines continue during hardly more than one to two hours daily, tends to raise the allowable percentage of line loss at maximum loads.

This is so because a loss of 20 per cent. at maximum load may easily drop to an average loss of somewhere between 5 and 10 per cent. for the entire amount of energy delivered to a line during each day under ordinary conditions in electrical supply. In the practical design of transmission lines, therefore, the sizes of conductors are influenced as much by the relation of the largest load to be operated to the greatest amount of power available for its operation, and by questions of regulation, as by considerations of all-day efficiency.

If the maximum load that must be carried by a transmission system during a single hour per day requires nearly as much power as can be delivered to the line conductors, either because of lack of water storage or of water itself, even if it is stored, it may be desirable to design these conductors for a small loss at maximum load, rather than to install a steam plant.

So again, as the fluctuation in voltage at the delivery end of a transmission line between no load and full load will amount to the entire drop of volts in the line at full load, if the pressure at the generating end is constant, the requirements of pressure regulation on distribution circuits limit the drop of pressure in the transmission conductors. For good lighting service with incandescent lamps at about 110 volts, the usual pressure, it is necessary that variations be held within one volt either way of the pressure of the lamps, that is, between 109 and 111 volts.

Every long transmission system for general electrical supply necessarily includes one or more sub-stations where the distribution lines join the transmission circuits, and where the voltage for lighting service is regulated. As the limits of voltage variations on lighting circuits are so narrow, it is necessary to keep the changes of pressure on the transmission lines themselves within moderate limits, or such that can be compensated for at sub-stations.

This is particularly true in cases where energy transmitted over a single circuit is distributed for both incandescent lamps and large electric motors, because the starting of such motors causes large fluctuations of amperes and terminal voltage on the transmission circuits. To hold such fluctuations within limits which a sub-station can readily compensate for, it is necessary that the loss in the transmission line be moderate, say within 20 per cent. of the total voltage delivered to it at maximum load.

Capacity and cost of equipment at generating stations go up with the percentage of line loss, and thus serve to limit its economical amount. For every horse-power delivered to a transmission line at a water power station there must be somewhat more than one horse-power of capacity in water wheels, at least one horse-power in generators, and frequently a further capacity of one horse-power in step-up transformers. Every additional horse-power lost in the line at maximum load, if the generating plant is to be worked up to its full capacity, implies an addition of somewhat more than two horse-power capacity in water wheels and generators, or of somewhat more than three horse-power capacity in water wheels, generators and transformers.

Since the cost of a generating station is thus increased as the maximum line loss is raised, a point is soon reached where any further saving in the cost of the line is more than offset by the corresponding addition to the cost of the station. Just where this point, as indicated by a percentage of line loss, is to be found depends on the factors of each case, important among which is the length of the transmission line.

This limit to line loss depends on the requirement for the delivery of a certain maximum power by a transmission line to its receiving apparatus, but is independent of the cost of production or the selling value of the transmitted power. Much effort has been made to fix some exact relation for maximum economy between the first cost of conductors for a transmission line and the amount of energy annually lost as heat therein. The best known statement applying to this case is that of Lord Kelvin, made in a paper read before the British Association in 1881. According to the rule there laid down, the most economical size for the conductors of a transmission line is that for which the annual interest on first cost equals the cost of the energy annually wasted in them.

If transmission systems were designed for the sole purpose of wasting energy in their line conductors, this rule would exactly apply, for it simply shows how the cost of energy wasted, plus the interest on the cost of the conductor in which it is wasted, may be brought to a minimum. As a matter of fact, transmission systems are primarily intended to deliver energy rather than to waste it, but of the proportions of the entire energy to be delivered and wasted, which is exactly what we want to know, the rule of Kelvin takes no account.

According to his rule, the cheaper the cost of power where it is developed, the less should be paid for conductors to bring it to market. The obvious truth is that the less the cost of power development at a particular point, the more may be invested in a line to bring it to market. If power cost nothing whatever at its source it would not be worth while to build any transmission line at all if this rule is correct.

A modification of Lord Kelvin's rule has been proposed by which it is said that the interest on the cost of the conductors and the annual value of the energy lost in them should be equal, value here meaning what the energy can be sold for. This rule is, if anything, worse than that of Kelvin, and would make the investment in line conductors much too large.

In the first place, the entire cost of production and transmission for the delivered energy should not be greater than the cost of a like amount of energy developed at the point where the delivery is made. In this entire cost of production and transmission, interest on the investment in line conductors is only one item, and yet the rule last named would make the interest on this investment equal the entire amount for which the power saved by the investment can be sold.

It is perhaps impossible to state any exact rule for the most economical relation between the cost of conductors and the loss of energy therein that will apply to every transmission. A maximum limit to the weight of conductors may, however, be set for most cases. This limit should not allow the annual interest and depreciation charges on the investment in line

conductors to raise the total cost of the transmitted energy above the cost of development for an equal amount of energy at the point where the transmitted energy is delivered.

While the maximum investment in transmission conductors may be properly limited in the way just stated, it by no means follows that this maximum limit should be reached in every case. In the varying requirements of actual cases, the problem may be to deliver a fixed amount of power at the least possible cost, or to deliver the largest possible amount of power at a cost per unit just under that of development at the point of use. Frequently a transmission system has a possible capacity in excess of present requirements, and a line that would not be too heavy for future business might put an unreasonable burden of interest charges on present earnings.

The foregoing considerations apply to the design of conductors for a transmission line after the voltage at which it is to operate has been decided on. Quite a different set of facts should influence the selection of this voltage. A transmission that would be entirely impracticable with any percentage of line loss that might be selected, if carried out at some one voltage, might represent a paying business at some higher voltage and any one of several sizes of line conductors. The power that could be delivered by a line of practicable cost, operated at one voltage, might be too small for the purpose in hand, while the available power at a higher voltage might be ample.

If any given power is to be transmitted with a fixed percentage of maximum loss in line conductors, the weight of these conductors will increase as the square of their length, and decrease as the square of the full voltage of operation in every case.

Thus, if the length of this transmission is doubled, the weight of the conductors must be multiplied by 4, the voltage remaining the same; but if the voltage is doubled and the line length remains unchanged, the weight of conductors must be divided by 4. With the length of line and the voltage of transmission either lowered or raised together, the weight of the conductors remains fixed.

An illustration of this last rule may be drawn from the case of lines designed to transmit any given power a distance of 10 miles at 10,000 volts, and a distance of 50 miles at 50,000 volts, in which the total weight of conductors would be the same for each line if the percentages of loss were equal.

This statement of the rule as to proportionate increase of voltage and distance presents the advantages of high voltages in their most favorable light. Though a uniform ratio between the voltage of operation and the length of line allows a constant weight of conductors to be employed for the transmission of a given power with unchanging efficiency of conductors, yet other considerations soon limit the advantage thus obtained.

Important among these considerations may be mentioned the mechanical strength of line conductors, difficulties of line insulation, losses between conductors through the air, limits of generator voltages and the cost of transformers.

If the 10-mile transmission at 10,000 volts, above mentioned, requires a circuit of two No. 1/0 copper wires, the total weight of these wires will be represented by $(5{,}500 \times 10 \times 2 \times 320) \div 1000 = 35{,}200$ pounds, allowing 5,500 feet of wire per mile of single conductor to provide something for sag between poles, and 320 pounds being the weight of bare No. 1/0 copper wire per 1000 feet.

When the length of line is raised to 50 miles, the two-wire circuit will contain $5{,}500 \times 50 \times 2 = 550{,}000$ feet of single conductor, and since the voltage is raised to 50,000 at the same time, the total weight of conductors will be 35,200 pounds as before. The weight of single conductor per 1000 feet is therefore only 64 pounds in the 50-mile line.

A No. 7 copper wire, B. & S. gauge, has a weight of 63 pounds per 1,000 feet, and is the nearest regular size to that required for the 50-mile line as just found. It would be poor policy to string a wire of this size for a transmission line, because it is so weak mechanically that breaks would probably be frequent in stormy weather. The element of unreliability introduced by the use of this small wire on a 50-mile line would cost far more in the end than a larger conductor.

As a rule, No. 4 B. & S. gauge wire is the smallest that should be used on a long transmission line in order to give fair mechanical strength, and this size has just twice the weight of a No. 7 wire of equal length. Here, then, is one of the practical limits to the advantages that may be gained by increasing the voltage with the length of line.

As line voltage goes up, the strain on line insulation increases rapidly, and the insulators for a circuit operated at 50,000 volts must be larger and of a much more expensive character than those for a 10,000 volt circuit. In this way a part of the saving in conductors effected by the use of very high voltages on long lines is offset by the increased cost of insulation.

Another disadvantage that attends the operation of transmission lines at very high voltages is the continuous loss of energy by the silent passage of current through the air between wires of a circuit. This loss increases at a rapid rate after a pressure between 40,000 and 50,000 volts is reached. To keep losses of this sort within moderate limits, and also to lessen the probability of arcs on a circuit at very high voltage, the distance of 18 inches or 2 feet between conductors that carry current at 10,000 volts should be increased to 6 feet or more on circuits that operate at 50,000 volts.

Such an increase in the distance between conductors makes the cost of poles and cross-arms greater, either by requiring them to be larger than would otherwise be necessary, or by limiting the number of wires to two or three per pole, and thus increasing the number of pole lines. These added expenses form another part of the penalty that must be paid for the use of very high voltages and the attendant saving in the cost of conductors.

Apparatus grows more expensive as the voltage at which it is to operate increases, because of the cost of insulating materials and the room which they take up, thereby adding to the size and weight of the iron parts.

Generators for alternating current can be had that develop as much as 15,000 volts, but such generators cost more than others of equal power that operate at between 2000 and 3000 volts. These latter voltages are as high as it is usually thought desirable to operate distribution circuits and service transformers in cities and towns, so that if more than 3000 volts is employed on the transmission line, step-down transformers are required at a sub-station. For a transmission of more than 10 miles the saving in line conductors by operation at 10,000 to 12,000 volts will usually more than offset the additional cost of generators designed for this pressure and of step-down transformers. If the voltage of transmission is to exceed that of distribution, it will generally be found desirable to carry the former voltage up to 10,000 or 12,000, at least.

As the cost of generators designed for the voltage last named is less than that of lower voltage generators plus transformers, step-up transformers should usually be omitted in systems where these pressures are not exceeded. For alternating pressures above 13,000 to 15,000 volts, step-up transformers must generally be employed. In order that the saving in the weight of line conductors may more than offset the additional cost of transformers when the voltage of transmission is

carried above 15,000, this voltage should be pushed on up to as much as 25,000 in most cases.

Power transmission with continuous current has the advantage that the cost of generators remains nearly the same whatever the line voltage, and that no transformers are required. Such transmissions are common in Europe, but have hardly a footing as yet in the United States. The reason for the uniform cost of continuous-current generators is found in the fact that they are connected in series to give the desired line voltage, and the voltage of each machine is kept under 3,000 or 4,000. As a partial offset to the low cost of the continuous-current generators and to the absence of transformers, there is the necessity for motor-generators in a sub-station when current for lighting as well as power is to be distributed.

In spite of the various additions to the cost of transmission systems made necessary by the adoption of very high voltages, these additions are much more than offset by the saving in the cost of conductors on lines 30, 50 or 100 miles in length. In fact, it is only by means of voltages ranging from 25,000 to 50,000 that the greatest of these distances, and others up to more than 200 miles, have been successfully covered by transmission lines. Above 60,000 volts there has been but slight practical experience in the operation of transmission lines.

The Gas Engine for Large Power Stations

THE tendency to spontaneous combustion of coal when stored in bulk,—in masses of, say, a thousand tons or thereabouts,—may appear to be a somewhat unusual point to make in favor of the gas engine as a large-size power unit for central station work. It was, however, made as such recently, says "Cassier's Magazine," by a central station engineer, whose contention was that the nearly always present danger of spontaneous ignition in the large reserve stock of coal expedient for a power station of any considerable size to carry, to tide over possible temporary interruptions in the supply, from strikes or other causes, was entirely eliminated by the use of gas engines which took their gas from central gas plants. Curiously, however, the fact appears here to have been overlooked that with the large gas engine plant will come, as an almost inseparable adjunct, the gas producer, taking the place of the steam boiler now accessory to the steam engine installation, so that the large coal pile will remain in evidence as before, and the spontaneous ignition troubles as well, even with certain precautions against them, in the way of selecting and storing the coal. Experience in some cases has dictated the safe height to which coal of certain sulphur percentage may be banked, but this height will vary with some other governing conditions easily enough imagined. The gas engine, therefore, will, after all, have to depend for favorable consideration upon its several other well-known good points rather than upon the one mentioned in the opening lines of this paragraph.

Electric Motor-Operated Hoists and Derricks

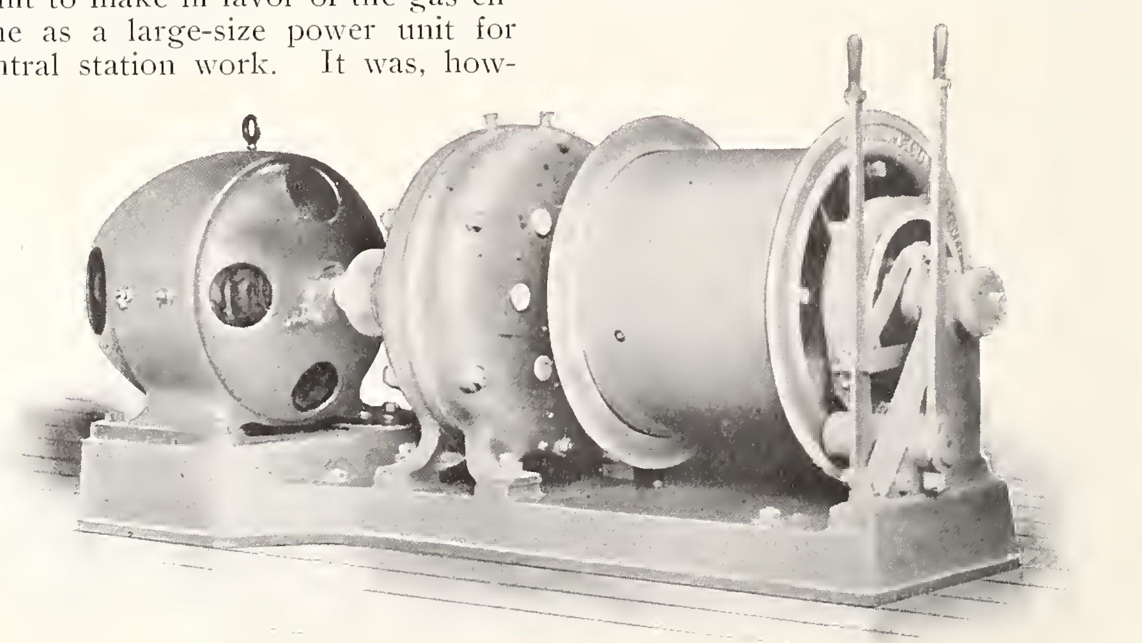
By HANFORD C. JUDSON

IT is too trite to say that necessity is the mother of invention; but engineers who have tried to introduce new improvements, have had the truth very strongly brought home to them that it must be a very great necessity to be the mother of progress. This is true particularly in lines of business that do not need technically trained minds to conduct them. The ordinary contracting and building trades were of this kind till very recently.

The writer remembers, and it does not seem so very long ago, when nearly every building presented a picture of a long line of laborers carrying hods and moving leisurely back and forth between the masons and the mortar heap or brick pile. Brick buildings were erected in this way in the days of the patriarchs. Then, complications with the labor organizations began to harass the contractor and boss builder, and so, when steam hoists were offered, they were quickly adopted by the more progressive firms, and the hod-carriers sought elsewhere for work.

The steam hoist is in use to-day, holding the field against the electric motor hoists, even in places where electric current is available and cheap, and this in spite of the fact that motor makers and hoist makers have been pleading the advantages of electricity over steam in this work for the past three or four years, or since the cost of electricity has been low enough to compare favorably with the cost of steam. This is due to several causes. The contractor knew his rough-and-ready steam hoist to be practically indestructible, while the less known and seemingly more delicate electric motor presented to his mind the possibility of frequent repairs and annoying care. Then the advantages to be gained by the electrical hoist were less palpable to his mind, in the form of dollars and cents, than the greater cost of the outfit. Again, it does not always happen that the actual cost of operating an electric hoist for any given time is less than the cost of running a steam hoist for the same time, and this has led some to think that idle claims have been made for the electric apparatus. If, however, the amounts of work accomplished by the two hoists for the same amounts of money had been compared, the case would, undoubtedly, have appeared in a different light.

Increased capacity for work is an advantage of the electric hoist which appeals strongly to contractors to-day, under present conditions of



A SEMI-ENCLOSED DIRECT-CURRENT MOTOR, DIRECTLY CONNECTED THROUGH ENCLOSED GEARS RUNNING IN A BATH OF OIL TO A SINGLE DRUM OPERATED BY A FRICTION AND CONTROLLED BY A FOOT BRAKE. MADE BY THE C. W. HUNT COMPANY, NEW YORK

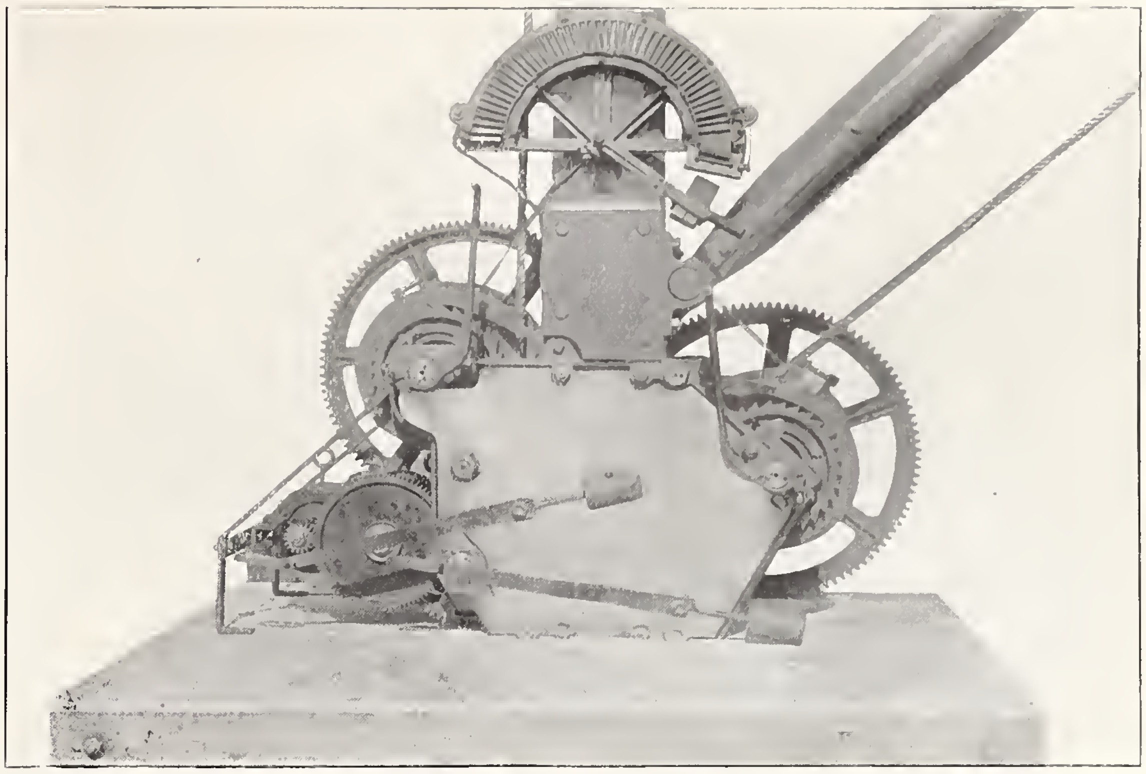
the labor market. As compared with the steam hoist, fully twice the work can be done with the same attendance by the electric outfit. When this induces firms to try the hoist, its other advantages are seen as well, and all of them have an opportunity of satisfactorily demonstrating themselves.

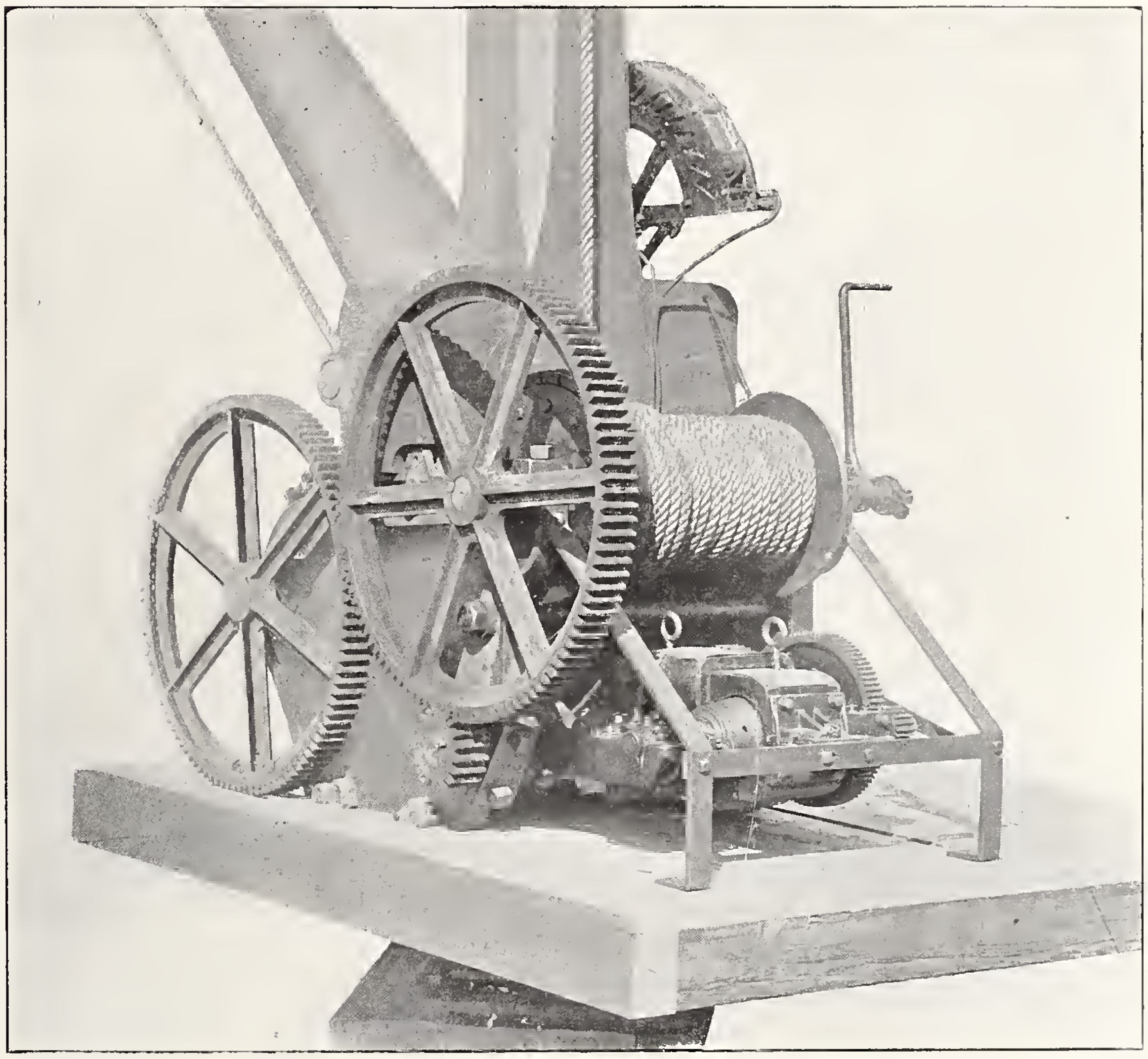
There are four types of electric motors suitable for contractors' work. For small hoists we have small direct-current, enclosed motors, or alternating-current motors, which run continuously and which need an exceptionally large friction gear on the hoist. For heavier work, continuously running alternating-current motors, or variable-speed direct-current motors may be used; but the customary practice is to employ the railway type of motor.

In the matter of initial cost of the hoists, the steam hoist has the advantage; but wherever it is adopted, the usual contractor's steam plant must be set up. This requires licensed attendance, in cold weather both day and night, for whether the plant is in operation or not, fires must be kept up and steam passing through the pipes to keep the drips from freezing. The electric motor, on the other hand, may be covered with a tarpaulin and thus left until required for service, and this in any kind of weather. The steam hoist is also invariably accompanied by a coal heap and an ash heap and an ever-present fire danger. Then, where marble or light-colored brick or stone is being used in the construction of a building, the smoke and soot are apt to increase the cleaning expense considerably.

The electric motor, without attendant danger from fire, may be brought inside and protected by a light shed, where it will neither obstruct the street nor be in the way of the builders. It may even be attached to the derrick itself and readily moved about a foundation excavation; or it may be lifted from floor to floor as the building progresses. It is noiseless, and so may be used in residence sections at night when a steam hoist might not be tolerated. It is not a delicate mechanism, but is built for and will stand any reasonably hard usage, and can be cared for and run by any one who has brains enough to come regularly to work.

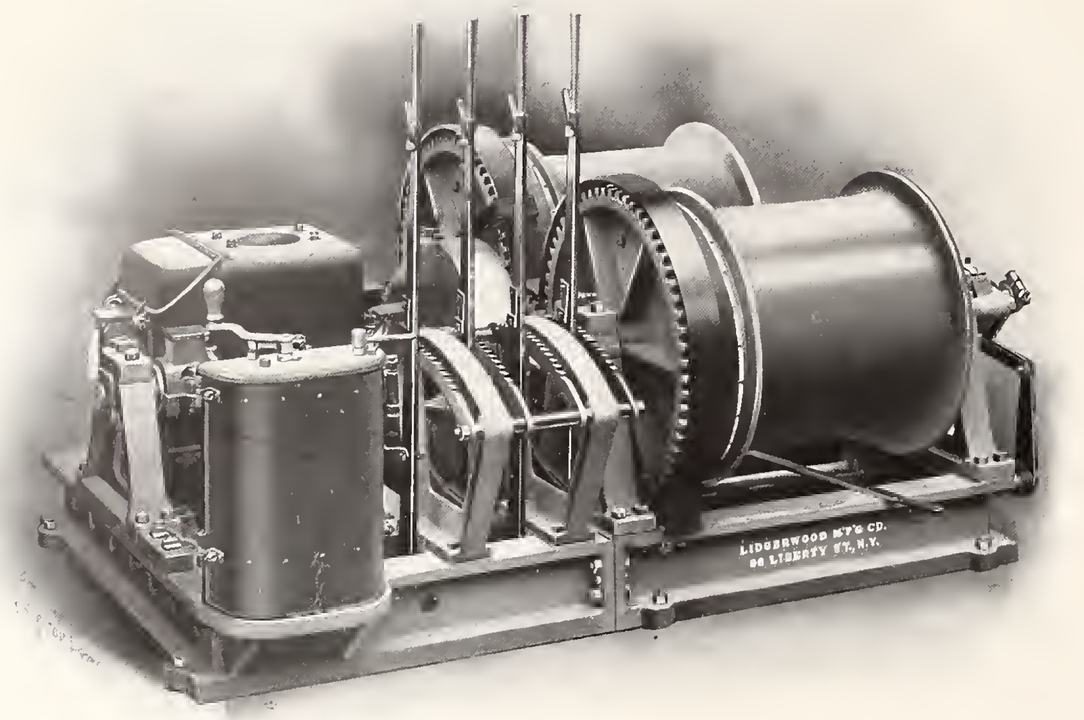
As an illustration that the application of electric motors to this work is by no means new, an illustration is given on this page of a hoist built nearly fifteen years ago by the early Thomson-Houston Company. The various motions of hoisting, topping the boom and swinging the derrick were adequately taken care of, and the hoist, even with its high-speed bipolar motor, was successful and is in operation to-day. A more modern application, however, of electricity, to this kind of work is shown at the new Public Library at New York, where eleven Lidgerwood triple-friction-drum hoists, driven by General Electric direct-current railway motors are in use. Each of these, with its controlling mechanism, is housed in a light shed inside the foundations. At a bell signal, the operator either lifts or lowers the fall, or the boom, or swings the derrick to the right or left. This last operation is performed by the third drum, from which a line is led around a grooved iron wheel or drum, fastened at the base of the upright to turn with it. The Lidgerwood Company has also arranged to control their hoists from a distance by levers, so that the operator can see the work himself.





AN EARLY TYPE OF THOMSON-HOUSTON ELECTRIC HOIST

One of New York's large building



A DOUBLE-DRUM ELECTRIC HOIST, MADE BY THE LIDGERWOOD MFG. CO., NEW YORK

contractors while lately excavating for a large building foundation, used a derrick driven by a Maine Electric Co. motor (see page 140) of the railway type, mounted on the upright about 6 feet from the ground. This has two friction-drums and, by means of bevel gearing, actuates a light steel shaft with a pinion at the lower end which engages an internal gear to swing the derrick about at will. This whole outfit is light and strong, and has great flexibility and quickness of operation. The driver, mounted on the upright with the hoist, always faces the work. This same kind of hoist is being used on one of the sections of the New York Rapid Transit subway. Another section of the subway is soon to be provided with a hoist similar to those used at the new Public Library building, previously mentioned.

A lately devised scheme for employing electric motors in sewer or trench excavation provides for a combination of a traction motor and a hoist motor, traveling on a rail supported by wooden bents erected about twenty feet apart, as shown in the illustration on page . As the work progresses, these may be continuously conveyed to the front by the traction motor. The telpher, or traction motor, supports the hoists by means of an arm, which clears the rail and is bent beneath it, giving perfect balance to the system. It is fed by two trolley wires and a cable return, and has no pendent cord or arm to be tripped and may be electrically controlled at one or at any number of convenient points. First the bucket is lowered into the trench; on being filled, it is lifted again, high enough to clear all ground obstructions and carried to carts, or it is dumped where its load may be useful for filling.

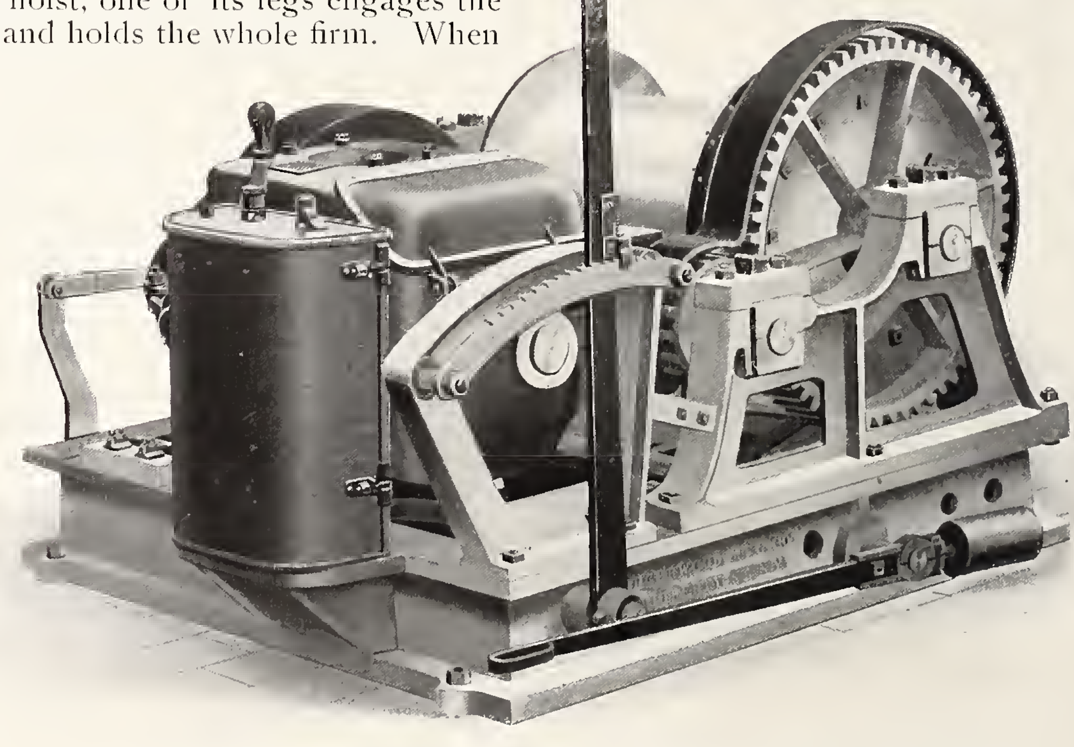
A telpher arrangement has also been devised for grading, as in railway work. An illustration of this is given on page 139. The scoop is lowered to the desired place and the telpher is moved forward far enough to give the hoist a working length of rope. The hoist, being started slowly, puts a strain on the rope, the telpher is kept from being drawn back along the rail by a steel strut, placed on the hoist arm, just under the rail, in such a way that when the arm swings even a little, due to the pull of the hoist, one of its legs engages the rail and holds the whole firm. When the scoop is filled it is lifted, carried away, dumped and brought back empty by the same controlling apparatus.

Trade Catalogues for Foreign Circulation

ONE of the favorite reasons advanced in behalf of the adoption of the metric system by the United States has always been that the system would be an important factor in the development of American export trade. As to this, Laurence V. Benet, artillery officer for Hotchkiss & Cie., of Paris, who have a large number of American machine tools in their factory, has said:—

"If American manufacturers wish to facilitate their export trade there are several things that they should attend to before upsetting existing standards of weights and measures. Of these the most important is the question of trade catalogues and price lists.

"American manufacturers get out the finest catalogues in the world, but they are all in the English language, and the dimensions and shipping weights are given in English measurements only. The example of German firms should be followed, and for the export trade all literature should be issued in English, French, and German, and for South America in Spanish. Dimensions and shipping weights should be given in English and in metric measurements, and all instructions regarding the setting up and handling of machines should be given in the language of the country concerned."



ANOTHER FORM OF ELECTRIC LIDGERWOOD HOIST FOR CONTRACTORS' SERVICE

Electricity in a Modern Newspaper Building

THE new building of the New York "Times," when completed, will, it is claimed, contain apparatus combining a greater number and a greater variety of uses for electricity than any other existing structure.

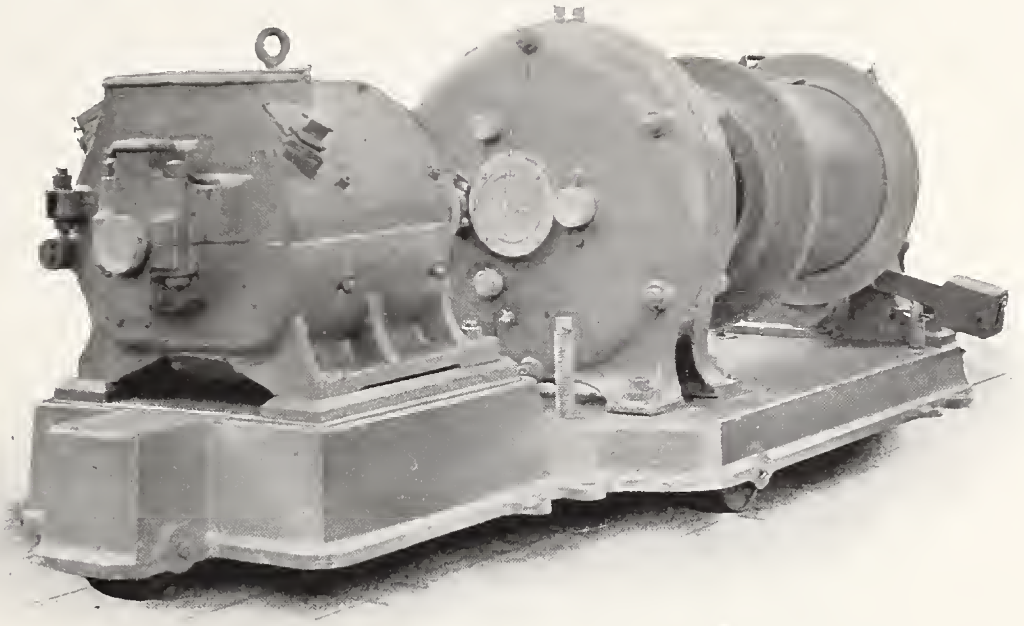
Steam, as the "Times" tells in a recent account of the installation, will be an unknown quantity in the building for the greater part of the year, as it will be used only for heating purpurposes, and at a pressure of less than 5 pounds. The dust brush and the traditional broom of the office sweeper will be banished. New ideas —new methods will prevail. These unique features are incidents that were evolved in the solution of a difficult problem.

The big presses in the second subbasement of the building rest on foundations 55 feet below the curb line of the street. In this deep pit it was proposed to locate a steam plant and elaborate devices for removing or cooling heated air that would necessarily be generated in the subterranean workroom. Then it was suggested to the management that the simplest, easiest, and most obvious way out was to avoid heating the air of the pressroom. The suggestion thus made raised that issue which every builder must determine for himself—the relative merits of an isolated plant or of outside electrical connection.

The cost of high-pressure steam installation, with the equipment for producing electricity for light and power was a considerable item, but the estimated cost of maintenance assumed greater importance than that of the cost of installation.

Reports obtained from the operation of various office buildings led to the decision that the Edison Central Station service was preferable, and the reasons for this conclusion were embodied in the following report:—

1. There would be a material saving first cost.



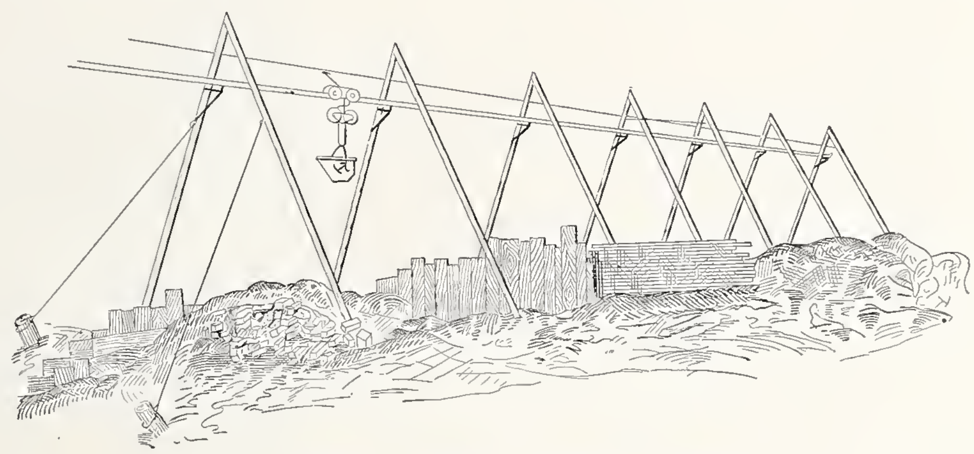
ELECTRIC MOTOR-OPERATED HOISTS AND DERRICKS. A 25-H. P. RAILWAY-TYPE DIRECT-CURRENT MOTOR DIRECTLY CONNECTED THROUGH ENCLOSED GEARS RUNNING IN AN OIL BATH, TO A SINGLE DRUM OPERATED BY A FRICTION AND CONTROLLED BY A FOOT BRAKE, THE WHOLE MOUNTED ON WHEELS TO PERMIT READY MOVING FROM POINT TO POINT. SUITABLE FOR WAREHOUSES AND WHARF WORK. MADE BY THE C. W. HUNT COMPANY, NEW YORK

AN ELECTRIC HOIST SUSPENDED FROM A TELPHER. MADE BY THE UNITED TELPHERAGE COMPANY, NEW YORK

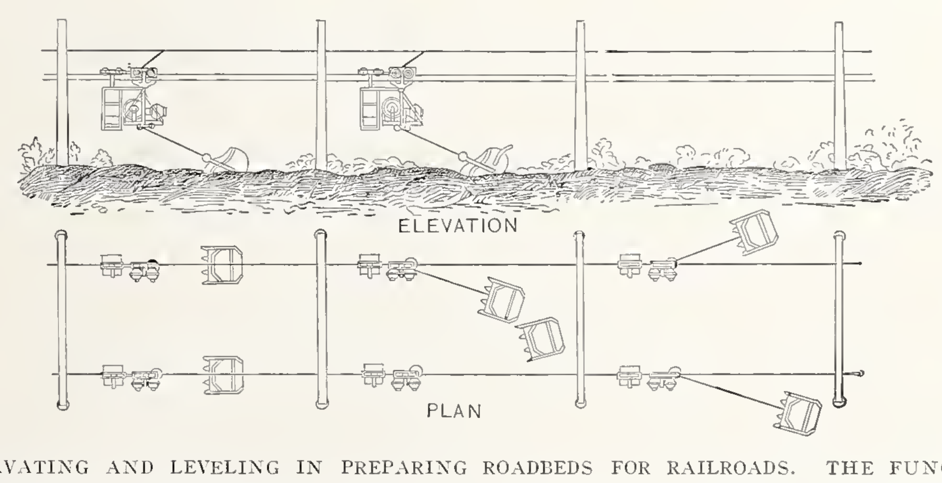
2. There would be a saving in annual cost of operation.

3. Valuable space in the sub-basement would be saved and utilized for other purposes.

4. For six months in the year there would be no fires in the basement, thereby avoiding that unbearable heat



THE TELPHER IN SEWER OR TRENCH EXCAVATION



EXCAVATING AND LEVELING IN PREPARING ROADBEDS FOR RAILROADS. THE FUNCTION OF THE TELPHER IS TO TRANSPORT THE HOIST, BUCKET AND LOAD. THE HOIST DOES THE EXCAVATING AND ELEVATING. THE HOIST AUTOMATICALLY BRAKES ITSELF EITHER UPON THE GIRDER RAIL OR GRIPS THE CABLE AS SOON AS THERE IS ANY LONGITUDINAL STRAIN. USED ALSO FOR SCOOPING AND TRANSPORTING EARTH, SAND, ASHES OR COAL

which attends a high-pressure steam system in the summer months, and to remove which the owner would ordinarily make a large annual outlay.

5. The pressroom plant should give better service at lower temperature.

6. The nuisances of receiving and storing coal and of taking out ashes would be avoided.

7. The bothers incident to the fluctuations in coal prices would be avoided.

8. The responsibilities that attend a steam plant in the employment of an operating force would be avoided.

9. The Edison service would give the insurance of independent connections with three Edison stations.

10. Vibration would be diminished.

11. There is no advantage to a building in the direct control of the production of steam.

12. In a period of ten years there has not been any general interruption of New York Edison service from any cause.

13. Many office buildings have relied for years and without embarrassment upon central station service for power and light. The "Times" has for some time past relied upon central station service for its power supply.

14. An experience in the summer of 1902, when the isolated plant broke down, emphasized the necessity for a "break-down" connection in a building which operates its own steam plant, and the cost of this connection must be reckoned as a part of the cost of maintenance.

15. All the requirements of a newspaper and of an office building, except those for heating in winter, can be met by electricity, and heat may be bought; anyhow, the cost of producing it on the premises is less than the difference between the annual cost of an isolated plant and the cost of Central Station service.

16. In a building containing rentable offices and a morning newspaper plant the electrical and steam installation must operate twenty-four hours, thereby reducing the life of the machinery and increasing the cost of annual depreciation.

17. The "Times" Building will have two peaks in its load diagram, one between 5 and 6 p. m., due to the lighting of the offices at that time, and the second peak of three hours in the early morning, due to the operation of the presses,—four hours in all. There would be no uniform load upon the plant. As a general proposition peaks and a lack of uniformity in load are not economical.

The reasons here given induced the "Times" to contract with the New York Edison Company for a six-year service, upon the stipulation that there would be independent connections with three supply stations of the Edison Company.

This outside electrical supply will furnish power for 109 motors, rated at 900 horse-power, light for 4,000 incandescent lamps, 15 arc lights, one searchlight, signs, bulletins, Cooper Hewitt lamps, and for many novelties, aggregating the use of current amounting to more than 400,000-kw. hours per annum.

The uses to which electricity will be put for newspaper purposes and for the needs of tenants may be enumerated as follows:—

111 MOTORS—

4 Hoe octuple presses.
1 job press.
1 electric proof press.
8 Kohler safety devices for controlling press movements.
2 autoplates, turning out eight stereo plates per minute.
38 linotypes.
3 house pumps.
3 sewake pumps.
1 air compression pump, for pneumatic tubes.
1 vacuum pump for cleaning carpets and offices.
1 ink pump.
1 paper conveyor, for carrying printed papers from presses to delivery room.
7 elevators, passenger and lift.
4 Leonard system of control for elevators.
1 gallery lift.
8 trolley hoists for paper rolls.

ELECTRIC MOTOR-OPERATED HOISTS AND DERRICKS. SEE PAGE 138. HOISTING CARTLOADS IN BULK FROM A BUILDING EXCAVATION, WITH AN ELECTRIC HOIST, INSTALLED BY THE MAINE ELECTRIC COMPANY, PORTLAND, MAINE

8 fans for metal pots and for ventilating pressroom.
6 gymnasium.
1 machine shop lathe.
1 " shop planer.
1 stereo molding machine.
1 " tail cutter, round.
1 " shaver, round.
1 " router.
1 " shaver, flat.
1 " trimmer, flat.
1 " saw.
1 " jig and drill machine.
3 refrigeration machines.

LIGHT—
4,000 incandescent lamps.
15 arc lamps.
Cooper Hewitt lamps.
Searchlight.
Signs.
Bulletin service.
Elevator flash.
Cigar lighters.
Carriage call.

HEAT—
Stereo matrix.
Restaurant, including plate warmers, coffee urns, tea kettles, egg boilers, griddles, self-dumping oyster cooker for stews, toasters.
Stereo pastepot.
Soldering irons.
Hair curler for ladies' toilet.
Heating pads.
Heating tailors' irons.

DENTAL—
Mallet.
Gold annealer.
Sterilizer.
Dental engine.
Mouth lamp.
Porcelain baking furnace.
Reflector for working on dark days.
X-Ray apparatus.
Cautery.

MISCELLANEOUS—
Time clock connection.
Fire alarm "
Telegraph "
Telephone "
Messenger call "
Office call "

Electrical novelties will be found in unlooked-for places. The presses will be equipped with the Kohler system of control, which permits of a movement delicate enough to turn the printing cylinder one-eighth of an inch per second, or at a speed of four revolutions per second. The automatic control and stoppage of machinery extends through the presses, autoplates, house pumps, sewage pumps, air vacuum pumps, and the air compression pumps, in order that current may not be wasted.

The plaza north of the "Times" Building extends for a distance of 1,000 feet. The suggestion has been made for the erection of an immense sign above the sixteenth floor which shall give carriage calls for the seventeen theatres in that vicinity to carriages waiting in this large area. For instance, the number 6 2 3 M would be a call from the Metropolitan Opera House; 5 4 2 E would summon a carriage to the Empire; 4 2 7 B would mean the Belasco Theatre, and 8 1 8 N would give notice from the New Amsterdam. In this way carriages for all theatres would have an ample space, the plaza would become the real center of midnight activity, and would reduce the inconvenience now caused by blocks and delays such as occur on opera nights.

The barber shop promises innovations that are sanitary and satisfying. Some of the latest shops have appliances for using what is practically a blowpipe on the hair, scattering fine particles into the surrounding air and giving provocation for a cold in the head. The vacuum system completely reverses that idea, providing treatment that is most pleasing and decidedly sanitary. Instead of whisks for clothing, hats, and shoes, the suction arrangement promptly and effectively removes all dust from clothing and sends it, with all the dust from the building, into a receptacle that will be collected once a day. The woman who scrubs the floors will abandon mops and will remove all the soapy or rinsing water by the suction of a pipe which has an opening 8 inches long and 1-16-inch in width.

Apart from the dust and noise and annoyance of present methods, there is a material saving to carpets and furnishings, all of which are aerated as well as cleaned. The particles of dust and disease germs that would otherwise float and fill the air disappear in the tube, and the service which has hygienic as well as commercial value is rendered.

The newspaper equipment—linotypes, presses, type cases, desks and furniture will be dusted and cleaned by this system, which will do away with brooms, brushes, pails and dirty water.

The electrical restaurant will include an outfit for cooking a full-course dinner; a patent range will broil a lobster in twelve minutes, lamb chops in three, and squabs in four minutes.

The hair curlers for the ladies' toilets and the contrivances for the gymnasium, restaurant, barber shop, dentist, tailor, and the photographic supply shop in the arcade, will have electrical novelties that will strike the fancy, but the equipment for the newspaper plant in the basement and for the offices above will make the "Times" Building especially interesting to those who are concerned with the larger application of electricity to commercial uses.

Water Power Development.

IN a paper read before the Frankfort (Germany) Congress of German Naturalists and Doctors, Dr. A. Gradenwitz gave an estimate of the water powers developed in several European countries and in the United States.

His figures are as follows:—Germany and Austria, 180,000 horse-power; Switzerland, 160,000 horse-power; Sweden, 200,000 horse-power; the United States, 400,000 horse-power. He estimates the total power available in a number of countries to be:—Sweden, 2,000,000 horse-power; France, 10,000,000 horse-power; Germany, Austria, Switzerland and Italy, combined, 10,000,000 horse-power; while in the United States, the Niagara Falls alone could furnish 10,000,000 horse-power.

Electric Tramways in Sweden.

Stockholm's electric tramways now in construction are to be ready for use early this year. The tenders accepted for the new lines were made by Swedish and German contractors in combination. The American bidders were unsuccessful in securing the contracts. The amount to be expended in this work is about 3,000,000 kronor ($795,000). Several other cities in Sweden—Gefle, Malmo, Norrköping, Sundsvall, and others—are contemplating exchanging their street railway lines from horse power to electric power.

The electrification of the Lancaster & Yorkshire Railway between Liverpool and Southport, England, comprising 23 miles of double line, is nearly completed. The power is carried through a third rail supported on insulators, with gaps at level crossings provided for safety, the third rail being bonded with cable underground. The trains are composed of two first-class and two third-class cars, 60 feet long and 10 feet wide, and having center passages.

The Western Union Telegraph Company now collects and distributes messages for the marine service of the Marconi Wireless Telegraph Company of America. The Postal Telegraph and Marconi systems have for some time past been working under a similar arrangement.

Electric Ovens

Baking with Niagara Power

By FRANK C. PERKINS

ELECTRICITY generated at Niagara Falls is now used extensively in baking what is known as "Triscuit" in the large cereal food plant of the Natural Food Company at that place. The electric ovens employed are shown in Fig. 1 of the accompanying illustrations. Four ovens are in use at the present time and two transformers are used for supplying them with the necessary current. These transformers are located on a platform above the ovens, together with a switch and voltage regulator. The latter permits a variation of 80 to 127 volts on the secondaries and a corresponding variation of temperature of the ovens. The transformers are of the oil-cooled type built by the Westinghouse Electric & Manufacturing Company, and each has a capacity of 140 kw.

The electric kitchen of the Natural Food Company's plant is equipped with the latest cooking apparatus and is used for preparing numerous dishes with the output of this plant. In the balcony which surrounds the main floor, there is a miniature electric railway, fully equipped with trains, stations, guards and electric switches, for serving visitors, who may be seated about the balcony, at small

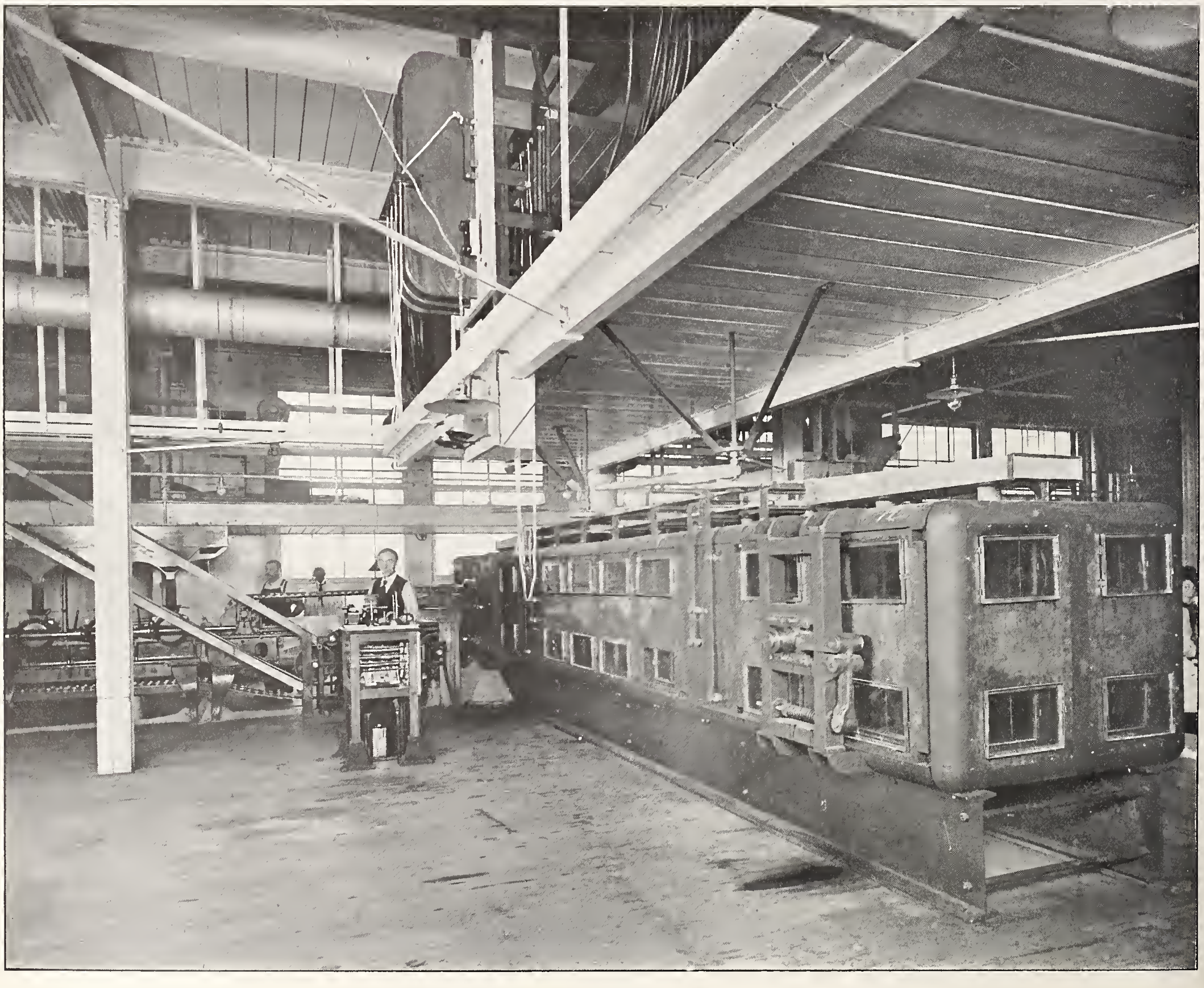


FIG. I.—ELECTRIC OVENS USED IN BAKING "TRISCUIT" IN THE KITCHEN OF THE NATURAL FOOD COMPANY, AT NIAGARA FALLS. THE TWO TRANSFORMERS SUPPLYING CURRENT TO THE OVENS ARE ON AN OVERHEAD PLATFORM, TOGETHER WITH SWITCH AND VOLTAGE REGULATOR. FOUR OVENS ARE INSTALLED AT PRESENT

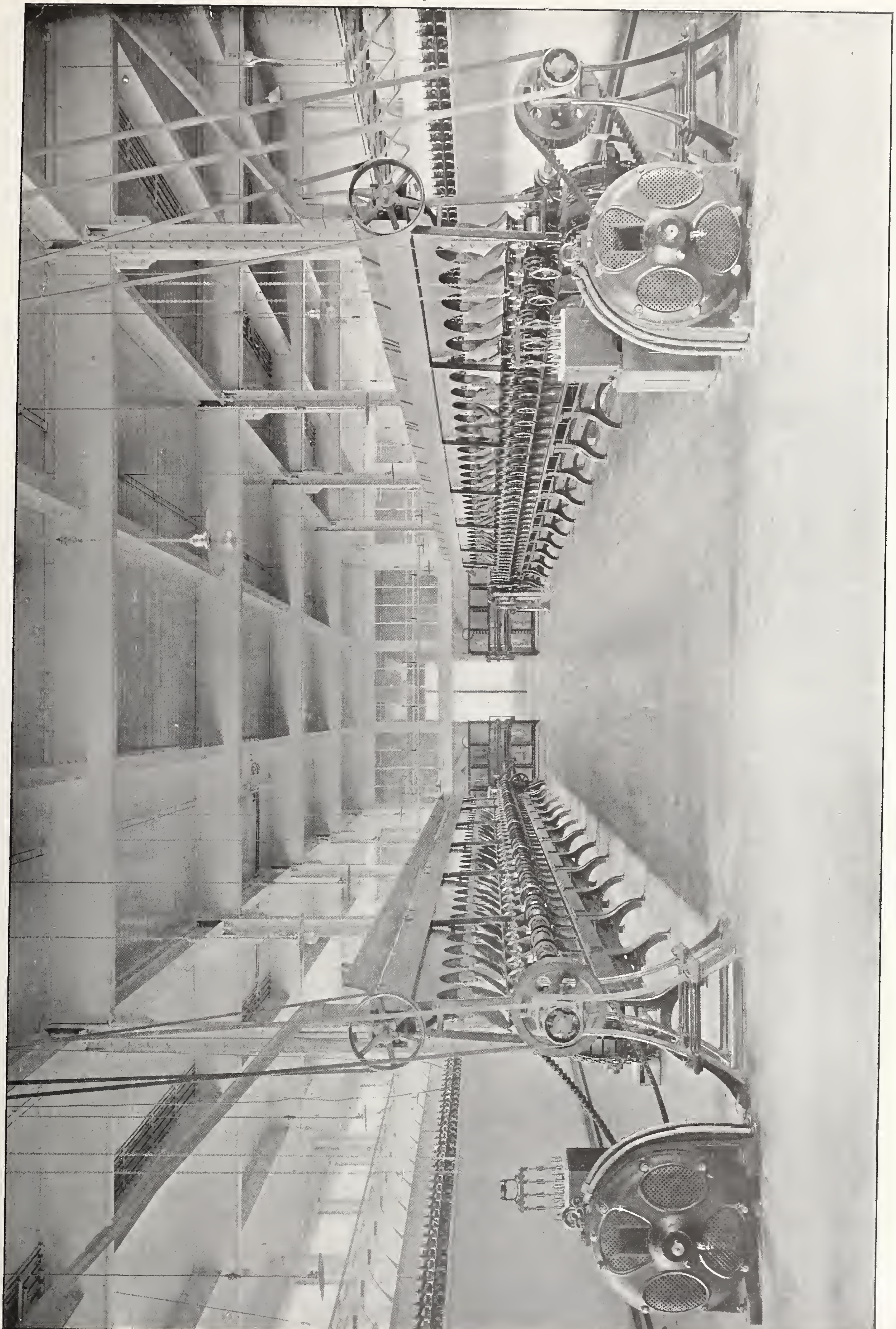


FIG. 2.—WESTINGHOUSE MOTORS DRIVING GANG MACHINES FOR SHREDDING WHEAT IN THE WORKS OF THE NATURAL FOOD COMPANY AT NIAGARA FALLS. THE WHEAT IS FED INTO THE HOPPERS ABOVE THE ROLLS, WHICH SHRED IT AND DEPOSIT IT ON AN ENDLESS CHAIN RUNNING UNDERNEATH

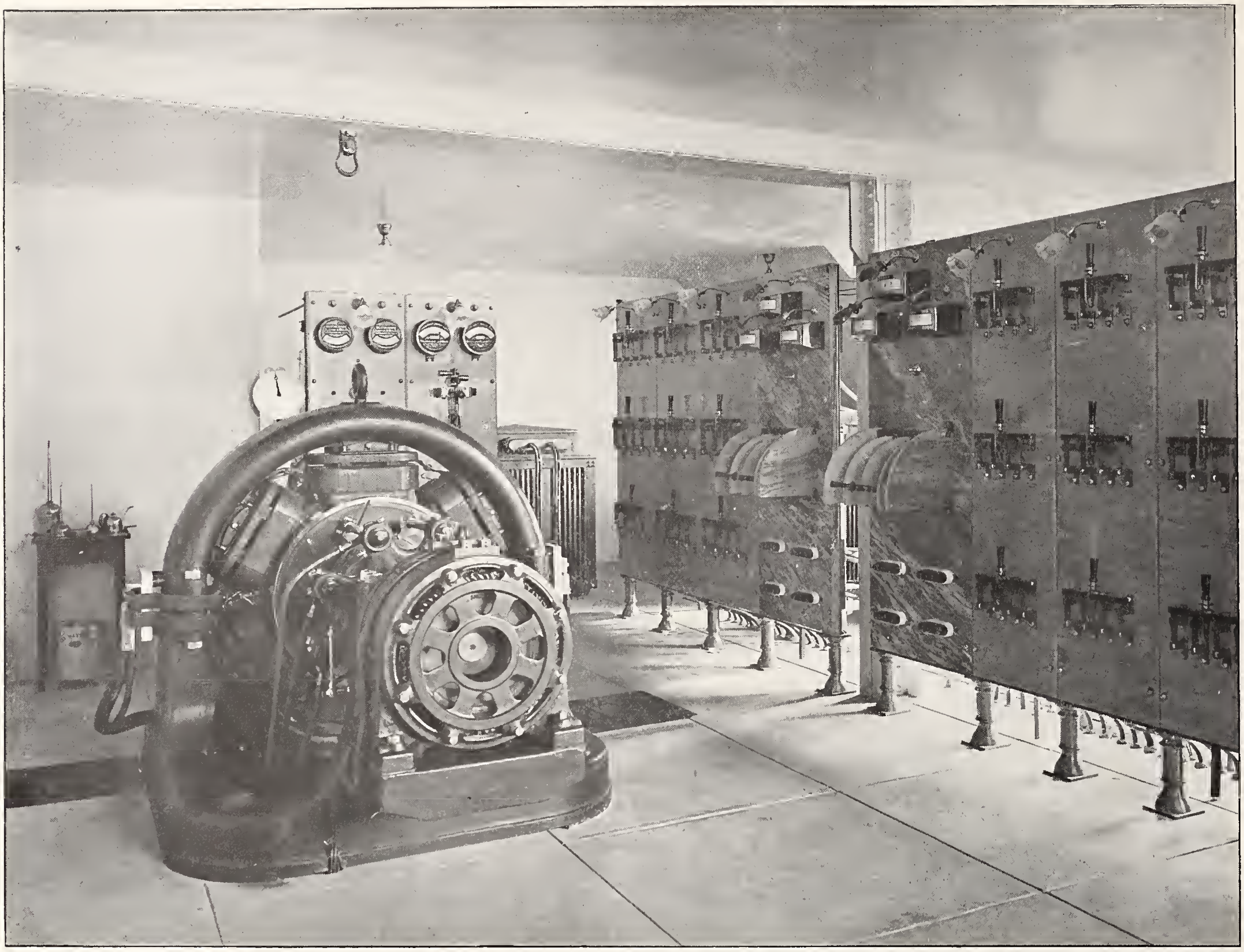


FIG. 3.—A VIEW IN THE TRANSFORMER ROOM

white tables, on which are located small electric cars forming the trays. A menu card is provided at a small desk in front of the guest, and when the order is written out and placed on the electric car, the pushing of an electric button signals to the switchboard attendant in the electric kitchen. The tiny car automatically travels to the kitchen on the main track, is supplied with the necessary order, and returns automatically to the station from which it started, with the luncheon attractively served, the car itself serving as a neat tray or table for the use of the visitor.

The electric cooking equipment is very complete. The apparatus includes chafing dishes, coffee and tea pots, and other utensils used for electric cooking demonstrations. The appliances are wired non-inductively and are indended to be used on a 110-volt current having a frequency of 25 cycles per second.

Fig. 3 shows a transformer room equipped with a 150 kw. Westinghouse rotary converter with switchboard and transformers in the background, the power and lighting boards being shown at the right. Fig. 2 shows two 40 horse-power Westinghouse induction motors driving two gang machines through Renold chains. Each machine consists of a series of thirty-six pairs of rolls which revolve towards one another. Wheat is fed into the hoppers above the rolls and, passing between them, is shredded and deposited on an endless chain running beneath the rolls.

Fig. 4 shows the terminal board located in the transformer room, provided with a circuit-breaker attachment designed to open the circuit-breakers in case the power goes off. It consists of a magnet in each phase and in series with a lamp. The two magnets hold a weight which in turn is attached to the tripping-lever of the circuit-breaker. A failure of the power on either phase allows the weight to drop and open the circuit-breakers.

There are six transformers; two of 75 kw. each, transform the potential from 2,200 to 110, and are used in lighting part of the factory; two of 150 kw. each transform from 2,200 to 440 volts and supply the motors in one half of the factory, while the two remaining transformers furnish current for a Westinghouse 150 kw. rotary converter. The latter furnishes a 220-volt direct-current for four Otis elevators and several ventilating fans.

The power and light switchboard in the transformer room was furnished by the Crouse-Hinds Company, of Syracuse, N. Y., and consists of nine panels. Two of these contain switches for cutting out the transformers. These panels also contain ammeters and voltmeters for each transformer. Three panels contain 440-volt switches, and four contain 110-volt switches. There is a second transformer room,—a duplicate of the one here mentioned, excepting as to the rotary converter, which is replaced by a 12 kw. motor-generator set.

On the third floor of the factory are located the six electrical baking ovens. These operate at about 100 volts, each oven being supplied by two 140 kw. transformers, one transformer being placed on each phase.

Power for operating the plant is obtained from the Niagara Falls Power Company, who furnish a two-

phase, 25-cycle, 2,200-volt, alternating current. The factory is located about three-quarters of a mile from the power house. The power is transmitted for a little over one-half of the distance on a pole line, the remainder of the transmission line being cables laid in conduit. At each end of the pole line the wires pass through a brick lightning-arrester house.

The factory is divided electrically into halves, each being supplied by its individual transformer room. The transmission line enters the east transformer room and passes to a switchboard panel containing main line switches, Westinghouse single-phase integrating wattmeters, and circuit-breakers. After leaving this panel the current supplies four sets of cables. Two sets, after passing through Westinghouse oil circuit-breakers, lead to transformers located on the third floor of the factory. These cables are of 300,000 c. m. copper with a 7-32-inch lead sheath. Of the remaining sets of cables, one supplies the east transformer room and the other goes direct to the west transformer room.

All cables leaving the transformer rooms are lead-covered and pass through a conduit system until they reach wire shafts, in which they rise to their respective floors and terminate in a distribution panel. There are four such shafts, permitting a division of each floor into four sections.

The equipment includes 85 Westinghouse induction motors operating on a 440-volt current. These motors vary in size from 1 to 40 horse-power. All the transformers are of the oil-cooled Westinghouse type.

The building is lighted by 2,500 Sawyer-Mann incandescent lamps, operating on the 110-volt, 25-cycle current, from the two transformer rooms.

Operating Electric Conduit Railways in Flooded Streets

In connection with the recently published statement that the operation of a sub-surface electric conduit railway in one of New York's water front streets would be impracticable because of frequent flooding of that street by high tides, it may be interesting to recall that several years ago it was repeatedly mentioned as a noteworthy circumstance that in the operation of the electric third-rail system on the Nantasket Beach Railway, in Connecticut, no difficulties in running trains had come from frequent flooding of the tracks, even though water, under usual conditions, is a fairly good conductor of electricity, and short-circuiting, one might suppose, ought to have resulted promptly when the tracks of that railway were submerged. In the city of Washington, too, the electric conduit line service on several occasions of flood was maintained without serious interruption.

That short-circuiting with submerged conductor rails does not necessarily occur was demonstrated many years ago, in the earliest days of electric railroading, when Mr. Leo Daft ran his historical little line at Greeneville, N. J. Mr. Daft had there laid down a short section of track, probably not more than an eighth of a mile long as it is now remembered, and ran back and forth on it a small motor car, purely for experimental purposes. At one point on the line there was a heavy depression, arranged intentionally, and the rails there were completely submerged; but notwithstanding this the little locomotive would spin along with undiminished energy, showing, as Mr. Daft intended, that the water over the rails had no injurious effect on the proper working of the line. In this instance, as in the case of the modern Nantasket Beach road, the simple explanation of an apparent impossibility was that while the water was a conductor, the rails were much better conductors and the electric current preferably followed them as being the lines of least resistance.

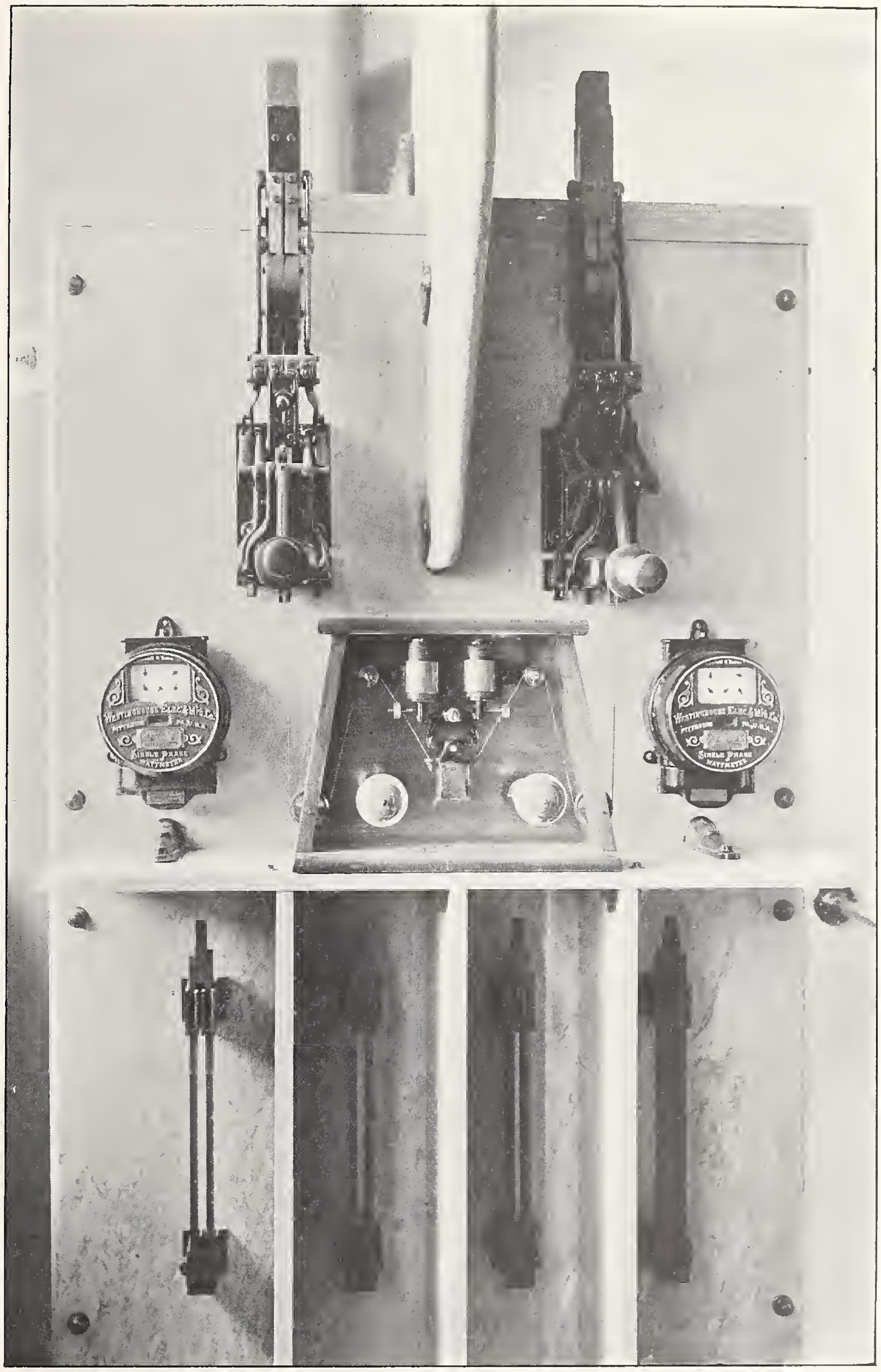


FIG. 4.—THE TERMINAL BOARD IN THE TRANSFORMER ROOM

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Leading Articles

Daily Newspaper Science

OUT of the number of clever people on the staff of a large metropolitan daily paper it would seem there would be one who would have the requisite technical knowledge to intercept the serious, but erroneous, conclusions on scientific subjects that more or less frequently appear in the columns of the daily press, and which the technical press is fond of terming "newspaper science."

An example of what is referred to occurred recently in an editorial based upon the telegraphic report of what purported to be a new invention, namely, the joint use of a wire for telegraph and telephone purposes. The editorial discoursed at length on the possibilities opened up by this invention, and made the usual prediction that if subsequent tests bore out the results of the first experiments, it would work a revolution in the arts of telegraphy and telephony. As a matter of fact, however, it is to be noted that the joint and simultaneous use of a wire for telegraphic and telephonic purposes was invented prior to 1884, and the system is to-day in use on hundreds of miles of wire. By the use of this system, the invention of Von Rysselberghe, a Belgian, two telegraph circuits are obtained from any metallic telephone circuit on which it is placed, without detriment to the operation of either system.

Another instance of non-familiarity with simple scientific facts is illustrated by an article that goes the rounds of the press once or twice annually, namely, the story of the electrified house. The article usually states that some one has discovered that everything he touches in his house, the radiators, picture frames, banquet lamps, etc., give him an electric shock. Hence, he fears there is some connection between the arc-light wires and the water pipes near his residence. The electric light inspector is, therefore, summoned, and reports that the wires of his company are intact and that the electricity must come from some other source.

It does not dawn on any of the people consulted that the discoverer of the phenomenon is unconsciously performing one of the simplest and oldest of electrostatic experiments, the shuffling of his shoes over the dry carpet raising the potential of his body to several thousand volts which discharge at every opportunity. One may even get electric discharges from his knuckles to the brass lock of a hand-bag which he may be carrying while walking on a stone pavement during cold, dry weather.

But, dismissing newspaper science, it is somewhat astonishing, in view of the many ways in which in cold, dry countries electricity is unintentionally developed and manifested by sparking, that the first knowledge concerning this phenomenon did not come to the ancients in this way rather than by the attraction of light substances by amber. The explanation of this, however, may be that the scientists of bygone days did not reside in cold, dry countries.

Business Training for the Engineer

TO the many things that have latterly been said as to the right kind of training for the young electrical engineer, as well as for his confrères in allied professional branches, it may well be added that instruction in business methods in engineering schools could be developed to excellent advantage.

In all the earlier courses of college instruction the business feature has been ignored, if not belittled, and the young men turned out by even the best schools have in most cases been without knowledge of even the rudiment of business practice. In engineering, as in every other kind of business, competition and the reduced margin of profits have in recent years stimulated the introduction of economies all around; they have emphasized the importance of conducting business on business principles and of closely following systematized ways of doing things that formerly had a happy fashion of shaping themselves to the best ends. It is not the science of rational book-keeping alone that has forced itself into recognition, but all the details of shop and office management as well, of estimating costs, of making stock surveys, recording

plant and buildings, of controlling correspondence and a small host of other things.

A few engineering schools have awakened to the fact that the engineer should have some commercial training, and courses of business lectures have been inaugurated in several of them, representing thus the beginning of a branch of instruction of which the need has clearly become imperative. The successful engineer to-day is a good business manager, and if he be college trained, he realizes, more, perhaps, than any college professor can realize, that business lectures during his technical course would have saved him much hard work in later years, much disappointment, and certainly, in many cases, money.

Electricity for Thawing Out Frozen Water Pipes

THE unusually long-continued and very cold weather of the past winter in the United States resulted in the freezing of thousands of water "service" pipes, causing great inconvenience in numerous instances, shutting off, as it did, the water supply from the buildings affected for days and sometimes weeks at a time. Nor has this freezing been confined to the service pipes. In many cases small mains in suburban localities were also frozen and the supply of water through the streets was thus stopped.

This state of affairs has not been limited to any one section of the country, but it has been more frequent in the East, where such prolonged cold weather has not been anticipated, and, in consequence, the pipes in many instances have not been laid to a greater depth than 3 or 4 feet below the surface. Owing to the fact that in many localities the ground has been frozen solid to a depth of from 5 to 6 feet, the question of digging down to the pipes for the purpose of thawing them has been a serious one.

The common practice in the vicinity of New York has been to build, on the surface of the ground, over the pipes a coal or coke fire, which is allowed to burn for from twelve to twenty-four hours to soften the earth sufficiently to permit digging. Numerous instances are known where plumbers have charged $100 for thawing out the service pipes in this way. To avoid this, or even a somewhat lower expenditure, many house-owners made temporary connections with the water pipes in adjoining houses, with the view of awaiting the thawing of the frozen water in the natural course of events. In other cases a temporary water supply was obtained by means of garden hose, connected from one house to the next.

In a number of cities and towns, however, an electrical means of thawing frozen pipes, which has been employed for some years in Canada and the Northwest was introduced in the East, and as this process is much more expeditious and cleaner than the plumber's fire method, and, besides, is very much cheaper, it was hailed as a boon by hundreds of property-owners.

The principle employed is very simple. An electric circuit is completed through the frozen pipe by attaching one wire of the circuit to the city hydrant and the other wire of the circuit to the water pipe or faucet in the building. Since the iron pipes are a much better conductor of electricity than the frozen earth, the electric current follows these pipes, heating them to a temperature sufficient to melt the ice within a comparatively short time after the application of the current.

The electric lighting companies in Newark, Jersey City and in other New Jersey cities, saw advantage to themselves in this use of the electric current, and in the last named city there were at one time several gangs of men engaged for several weeks thawing out frozen water pipes at the rate of from fifteen to twenty-five per day. The current was taken from neighboring electric lighting circuits, which happen to carry a 2,000-volt alternating-current. Connection was made with the overhead wires, and the pressure was reduced by portable step-down transformers, carried on wagons, to a pressure of about 20 to 50 volts. For further regulation of the pressure and current, suitable coils and water rheostats, or resistances, were employed.

The charge for this service in Jersey City has been twenty-five dollars; in Newark it has been fifteen dollars. In the first-named city the electric company gave the monopoly of this work to a local plumber; that is, the plumber took the orders and sub-let the work to the electric lighting company, an arrangement which brought down the wrath of the victims upon the heads of the lighting company. This monopoly, however, although it lasted long enough to enable those concerned to reap a rich, if begrudged harvest, was interrupted by the advent upon the scene of a local manufacturer who, having a spare gas engine and dynamo machine, mounted them both upon a wagon and undertook the work of thawing out water pipes at ten dollars apiece. In other cities storage batteries, carried on wagons, have been utilized for this work.

In the application of electricity to the thawing out of water pipes, it is, of course, essential that care be taken not to heat the water pipes sufficiently to injure them, and for this reason the current is thrown on the pipes at a low strength, which is increased gradually. For large pipes, heavy current of low voltage is used, and for small pipes comparatively low current is employed. In some instances a current ranging from 25 to 300 amperes is employed, and in the case of frozen mains as much as 1,000 amperes have been utilized for a few minutes. With a service pipe 75 feet long, a current of 275 amperes, at about 18 volts pressure, has raised the temperature of the pipes to about 145° F.

It is obviously very desirable to avoid digging up the street to make the necessary electrical connection with the pipes, and, as already noted, connection is made with the street hydrant for one terminal of the circuit wherever this can be done advantageously; but in some cases the hydrant is too remote. The circuit in that event must be completed by conecting up with the outlet pipe in one house to the outlet pipe in an adjoining or nearby house. But in the case of isolated buildings it is imperative to dig down at one point to reach the pipes.

In the foregoing it has been assumed that the water pipes to which the electrical thawing-out process is applicable are of iron. In one case in a neighboring city the best part of a day was wasted in the attempt to thaw out an unusually refractory pipe before it was learned that earthenware water mains were used in that section. Such pipes, being non-conductors of electricity, of course could not be heated in this way as no current will flow through them.

It is so common a thing to read that fires of mysterious origin were doubtless caused by a defective electric light wire that it is something of a surprise to learn from some recently published statistics on fire losses and causes that out of a total of 30,800 fires in the United States in one year but 1,054 were traceable to electricity. On the other hand, the fires arising from this cause occasioned the highest average loss per fire. By far the largest portion of the fires causing losses of about 66 per cent., were due to the use of coal in some shape,—defective flues, stoves, sparks from locomotives, furnaces, etc.

Incandescent Electric Lighting

Its Birth and Development

By W. S. ANDREWS

THE twenty-fifth anniversary of the Edison incandescent lamp and the fifty-seventh birthday of its distinguished inventor, were very fittingly celebrated at the annual dinner of the American Institute of Electrical Engineers at the city of New York, on the evening of February 11, 1904. The interest of this memorable occasion was further enhanced by the presentation of the deed of gift of the Edison Medal to the Institute with an endowment fund of something over $5,000. Mr. Edison was naturally the guest of honor and his presence was especially appreciated by those who had been privileged to assist him in his early work in the development of incandescent electric lighting.

Previous to the year of 1878, the use of electricity for domestic lighting, on a footing with gas, had not received any serious attention, and the incandescent electric lamp could be considered only as an interesting, but practically useless, laboratory experiment. In that year, however, Edison began to take an interest in the subject, and in September, 1878, he produced his first incandescent lamp, which consisted of a spiral of platinum wire suspended in a closed chamber and raised to incandescence by a current of electricity.

Even at that early date Edison had evolved well-defined ideas in regard to the subdivision of the electric light, and also on the general house-to-house service of electricity and the possibilities of the general application of electricity to other purposes than lighting. His wonderful foresight in those matters will be recognized in the following extract from the New York "Sun" of September 16, 1878. In an interview with a "Sun" reporter at his laboratory in Menlo Park, N. J., he said:—

"I can produce a thousand,—aye, ten thousand (lights) from one machine. With fifteen or twenty of these dynamo-electric machines, recently perfected by Mr. Wallace, I can light the entire lower part of New York City, using a 500 (?) H.P. engine. I purpose to establish one of these light centers in Nassau street, whence the wires can run uptown as far as the Cooper Institute, down to the Battery and across both rivers. These wires must be insulated, and laid in the ground in the same manner as gas pipes. I also propose to utilize the gas burners and chandeliers now in use. In each house I can place a light meter whence these wires will pass through the house, tapping small metal contrivances (i. e. lamp sockets) that may be placed over each gas burner.

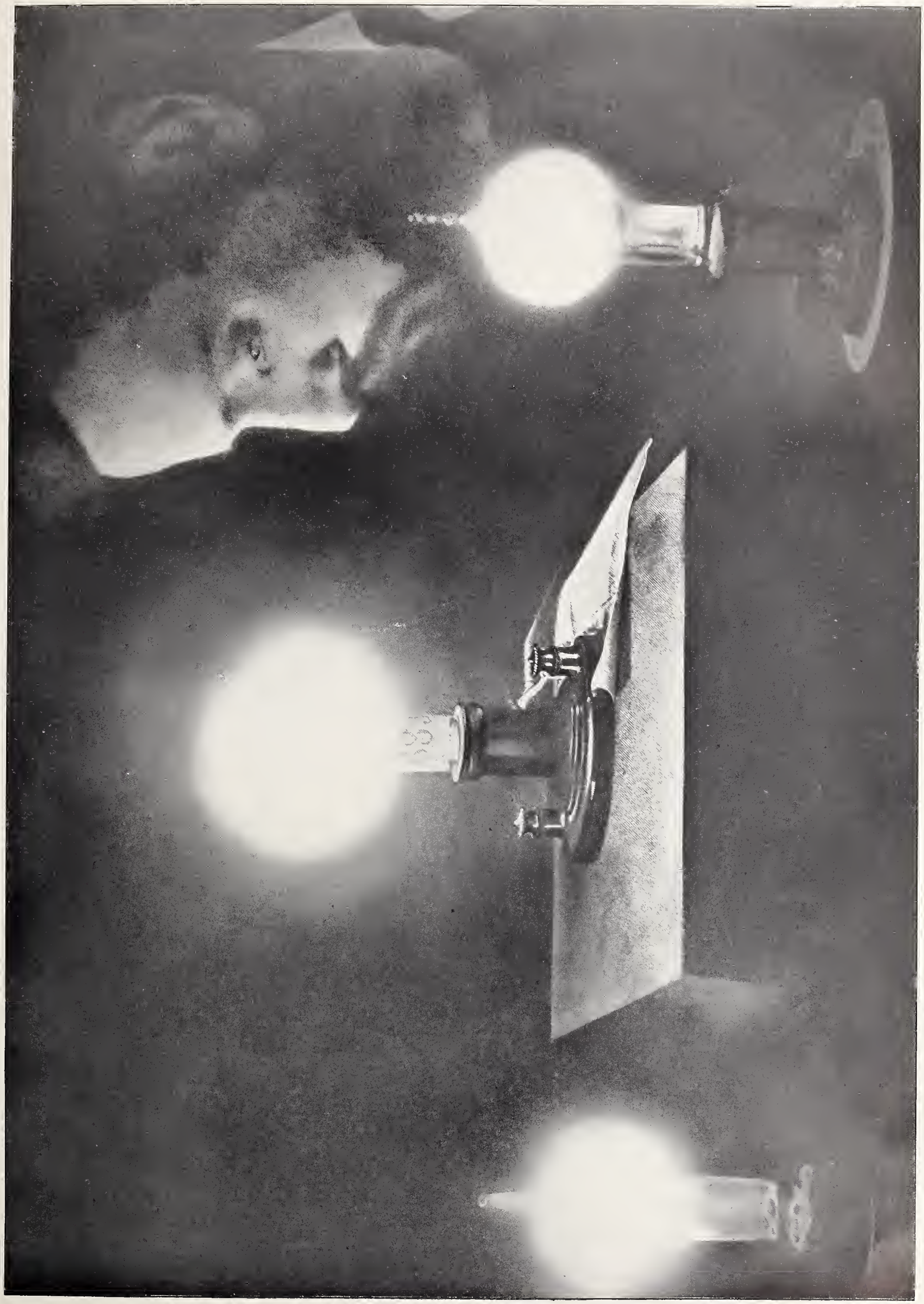
"Again, the same wire that brings the light to you," Mr. Edison continued, "will also bring power and heat. With the power you can run an elevator, a sewing machine or any other mechanical contrivance that requires a motor, and by means of the heat you may cook your food."

Could any statement have been more prophetic than this, or have more faithfully outlined the present utilization of electricity for domestic purposes?

After many months of strenuous and incessant experimenting with the incandescent platinum spiral, its unfitness for commercial lighting became finally apparent, but at that moment of discouragement a substitute for platinum was discovered and Edison's first carbon filament lamp was produced.

The following extract from the

THE FIRST INCANDESCENT CENTRAL STATION IN THE WORLD—APPLETON, WISCONSIN, 1882—ONE DYNAMO, FIFTY LIGHTS



THE FIRST PHOTOGRAPH EVER TAKEN BY INCANDESCENT ELECTRIC LAMPS

By Kind Permission of W. J. Jenks.

EDISON AT THE AGE OF FOURTEEN

THE BIRTHPLACE OF EDISON, AT MILAN, OHIO

New York "Herald" of December 21, 1879, briefly relates the pleasing story:—

"Edison's discovery of a substance from which electricity could produce the light of incandescence with comparative inexpensiveness and perfect effect, is one of those little romances of science with which the pathway to every great invention is strewed. Platinum was a great obstacle for a while in this hunt; and not altogether satisfactory in operation, while of extremely high value, it seemed, at the moment, as if it might make the search altogether vain. But the happy discovery of the uses of a bit of cotton thread has turned the whole current of this story into a fortunate channel, and we are rejoiced to congratulate not merely Edison, but the people of all civilized nations upon Edison's success."

The first carbon filament lamp was made on or about October 22, 1879. The writer was living at Newark, N. J., at that time, and he well remembers reading the statement in a local paper that Mr. Edison had sent to Clark's Thread Works, at Newark, for a pound of the best cotton thread, and that he had produced a wonderful lamp by carbonizing the cotton and then passing a current of electricity through a short piece of it.

About this time Edison also began to actively develop all the details for the transmission and distribution of electricity to be used in connection with the new lamp. He attacked the problem with his characteristic ardor and indomitable perseverance, and with the determination to evolve a system of electric lighting with incandescent lamps which would be so cheap, convenient, and safe, that it could be used for public and private lighting purposes in competition with gas.

The Edison Electric Light Company had been incorporated in 1878 with a capital of $300,000 for "the production of light, heat and power by electricity," and being thus furnished with ample funds for the work in hand, Edison fitted up the laboratory and workshops at Menlo Park with all necessary machines and appliances, and employed as his assistants a staff of picked men who worked

FOUR YEARS OLD

enthusiastically almost day and night in the development of the new system.

The first lamp filaments, as before stated, were made of carbonized cotton thread; but these were found to be too fragile and uneven in texture. Annular and horse-shoe filaments were then cut from paper and thin cardboard and were carbonized; these gave better results. Steel moulds were made, and powdered graphite was formed into filaments under enormous pressure; but they turned out to be brittle and soon fell to pieces. An ingenious machine was also made which automatically shaped the horseshoe filaments out of hard wood, and countless filaments were cut out of all varieties of native and foreign woods. These were carbonized and made into lamps which gave more or less satisfactory service. In fact, almost every conceivable kind of carbonized material was experimented with in the effort to improve the efficiency and durability of the lamp, and agents were sent to many foreign countries to collect all kinds of vegetable fibers which might possibly possess the desired qualifications.

It was at length discovered that filaments cut from the hard outside shell of a certain variety of the bamboo cane, and then carbonized at a high temperature, gave the best results. This product was therefore adopted and used for many years.

The discovery of a suitable material for the incandescent lamp filament was naturally only a small part of the work to be accomplished, for Edison had laid out the task of designing a comprehensive lighting system which was to be complete in all details, from the generators to the lamps. This system was, moreover, entirely new and untried, inasmuch as it was to be a constant-potential multiple-arc system in which each lamp would be an absolutely independent unit that could be lighted or extinguished without affecting any other lamp on the system. All previous electric lighting had been accomplished with lamps connected in series, each lamp burning normally at a certain voltage, thus involving a total voltage higher in direct proportion to the number of lamps, and precluding the possibility of indefinite sub-division.

Edison's new lamp and system of sub-division of the current were severely criticised and ridiculed both in this country and in Europe by many eminent scientists who pronounced the entire scheme to be simply a revival of old ideas, long since tried and discarded by earlier inventors. Edison, however, had thoroughly studied his ground and, having absolute faith in the practicability of his conceptions, no discouragement could cool his ardor or weaken his belief in final success.

Throughout the year 1880 the work of development progressed steadily and simultaneously in all the many branches of the new system. Various shunt-wound generators were designed, built, and operated under different conditions. The incandescent lamps were continually improved, and every now and then new batches of them were set up in the grounds around the laboratory and in the surrounding residences, to test their utility in practical commercial service. The electric meter also received careful attention, as Mr. Edison, with a keen appreciation of future requirements, considered this device to be an indispensable adjunct to his system.

EDISON'S MENLO PARK LABORATORY IN THE WINTER OF 1879

Lamp sockets, switches, and safety appliances had also to be devised, constructed and tested. Nearly everything in connection with the system had to be originated, as the conditions of operation were new and untried, and there were very few landmarks to point the way in these hitherto untrodden fields.

After many months of arduous work, shadowed by some discouraging failures, but brightly illuminated

THE LATEST PORTRAIT OF THOMAS ALVA EDISON, FROM A PHOTOGRAPH TAKEN BY FALK ON FEBRUARY 11, 1904, THE FIFTY-SEVENTH ANNIVERSARY OF EDISON'S BIRTHDAY

A SNAPSHOT IN THE LABORATORY AT ORANGE, NEW JERSEY

Copyrighted by W. K. L. Dickson

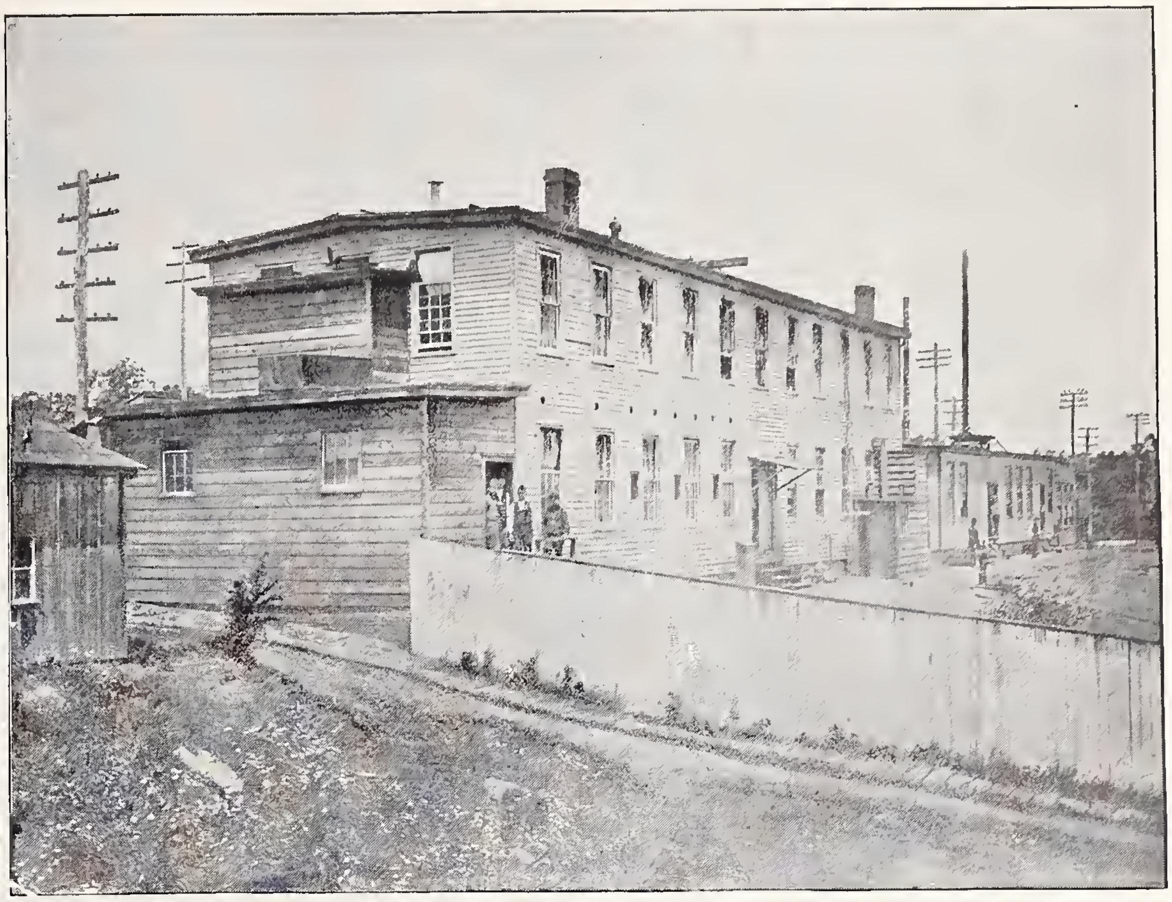
by final success, Edison was so far satisfied with all details that he determined to give a public exhibition of the light on a grand scale. A number of wooden lamp posts were erected and fitted with outside globes of clear glass to protect the lamps and sockets from the weather; insulated conducting wires were laid underground from post to post, and at length, in the early winter of 1880, the work of installation was finished. The preliminary tests were completed, the results found satisfactory, and the snow-covered woodlands around Menlo Park laboratory were illumined night after night by glittering rows of incandescent lamps which presented much the same appearance as those with which we are now familiar.

This exhibition was continued for several months, and the installation was enlarged from time to time until nine electric generators were eventually put into simultaneous service to supply current to 600 16 candle-power lamps through about eight miles of underground conductors, the area lighted being approximately one mile long by half a mile wide. Envious rivals and chronic doubters had by this time been almost silenced by the unqualified success of this magnificent display to which all the world had been unconditionally invited, and the appreciation of the public and the press may be fairly estimated by the following extract from the "Scientific American" of June 18, 1881:—

"Simply as an exhibition of perfect illumination under perfect control, covering a vast area, this array of lamps presents a most remarkable and delightful sight, and is alone well worthy of a trip to Menlo Park. As a demonstration of the perfected working of a great and novel system of illumination, sure to become in a little while, a potent contributor to the comfort and economy of city life, it is a spectacle which cannot fail to impress powerfully the mind of any observer."

In response to Edison's cordial invitation, thousands of people from far and near came to see the wonderful exhibition at Menlo Park, which marked the beginning of the industrial era of domestic electric lighting, and the daily papers were filled with all the marvelous possibilities of the new illuminant.

Orders for dynamos and accessories came in so fast that the facilities of the Menlo Park shops were found inadequate to supply the demand, and the works of the John Roach Machine Company, in Goerck street, New York City, were therefore purchased by Edison and his associates for the manufacture of electric apparatus on a large scale.



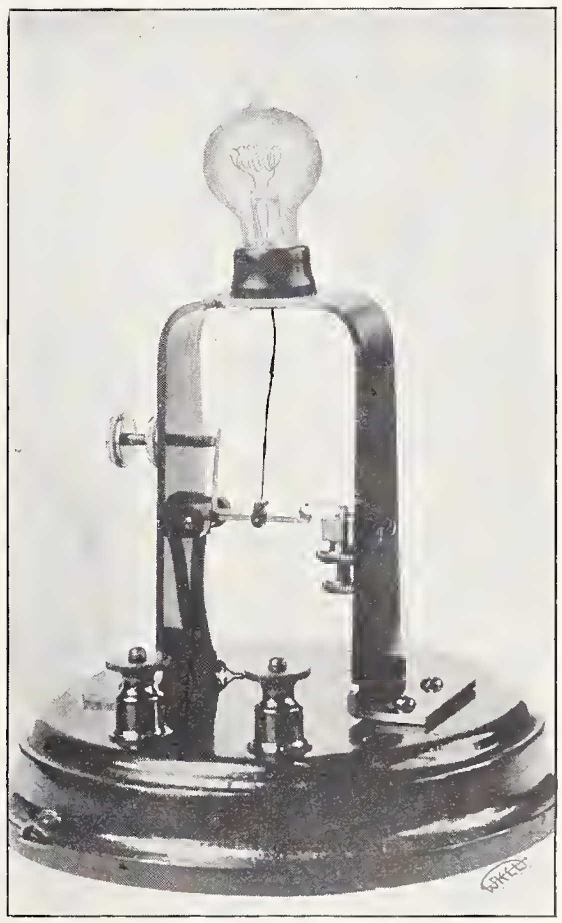
THE LAMP WORKS AT MENLO PARK IN 1880

Although there was a wide field for small isolated lighting plants, it was Edison's aim from the start to promote the installation of central stations where electricity could be cheaply produced by powerful generating units and distributed from house to house through overhead or underground conductors, and early in 1880 he began to build massive shunt-wound bipolar generators suitable for direct connection to high-speed steam engines, these units being specially adapted for heavy central station duty.

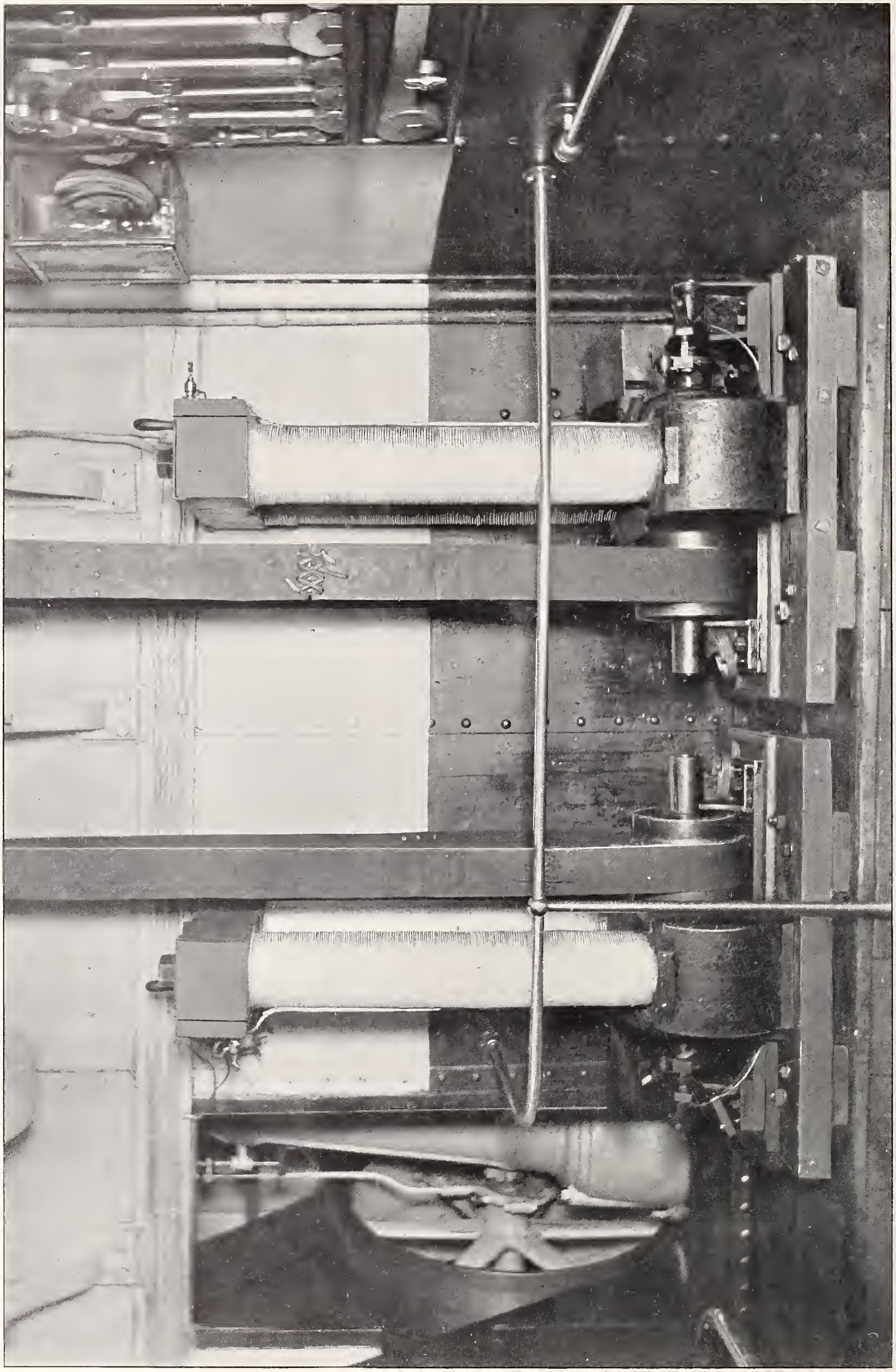
One of these "Jumbos," as the machines were facetiously named, created a great sensation at the Paris Exposition in 1881, and several similar machines were afterwards built and operated in the city of New York, and also in London, Milan, and other industrial centers.

The first central station in the world designed for the public service of electricity for incandescent lighting was started in Appleton, Wis., early in 1882. This was a very modest affair, having only one small dynamo driven by water power. A month or two later a comparatively large station was opened in Holborn Viaduct, London, England, and on September 4, 1882, another station was started in the city of New York. This was the historic Pearl street station. In this six "Jumbo" generators supplied current to customers through about eighteen miles of underground feeders and mains on the two-wire system, which made the cost of copper enormous. To overcome this drawback, Edison invented the well-known three-wire system which is now universally used for continuous-current distribution in all large cities in this country and elsewhere.

The first central station installed on the three-wire system was built at Sunbury, Pa., and as this was the banner plant of its kind, it may be inter-



EDISON'S FIRST LAMP. THE FILAMENT CONSISTED OF A SPIRAL OF PLATINUM

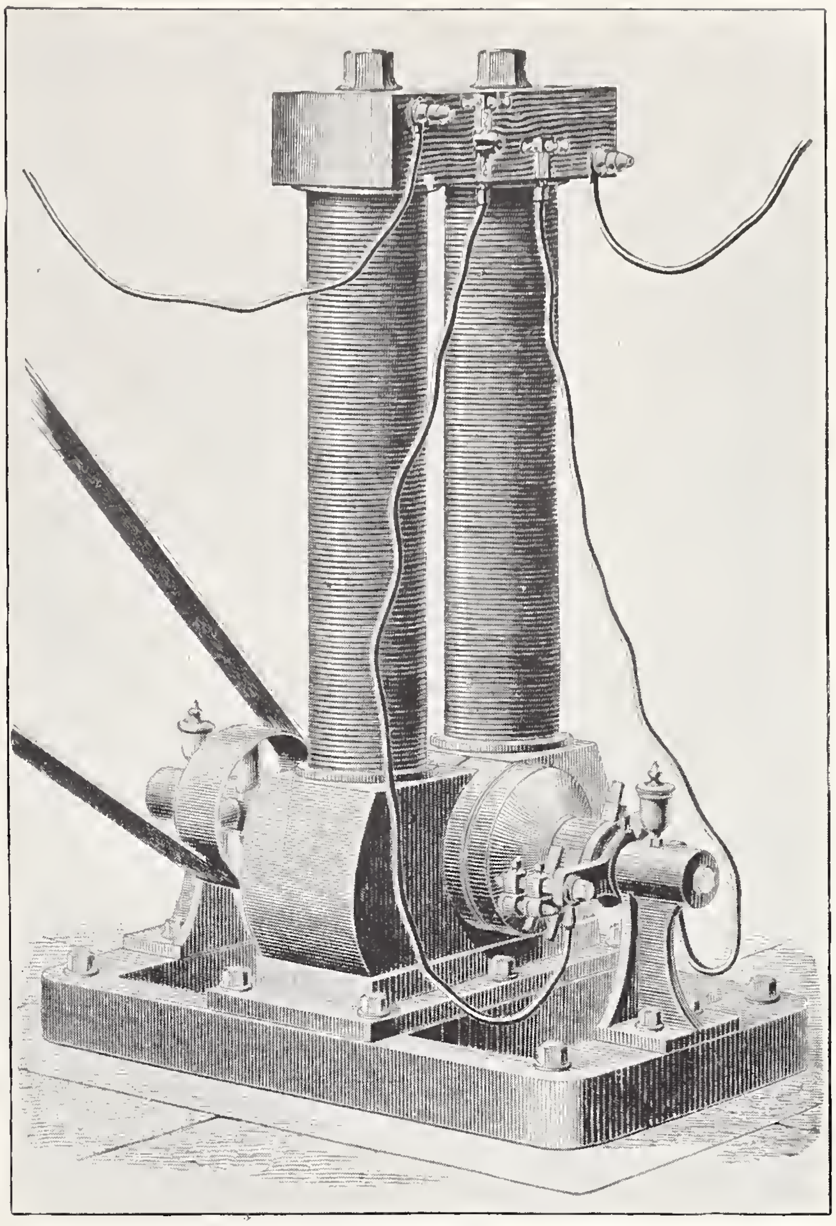


IN THE ENGINE ROOM OF THE STEAMSHIP "COLUMBIA," 1879. THE EDISON GENERATORS HERE SHOWN WERE AMONG THE EARLIEST IN PRACTICAL USE

By Kind Permission of W. J. Jenks.

esting to briefly review some details connected with its history. Early in the spring of 1883 Edison desired the writer to make some tests at the Goerck street works on his newly invented three-wire system of electrical distribution, and the results shown were so highly satisfactory that it was determined to put the system into immediate commercial operation at Sunbury. The station contained an engine and dynamo room, meter room and boiler room, and the electrical equipment consisted of two Edison bipolar generators driven by an Armington & Sims engine with a total capacity of about 400 16-candle-power lamps. The bus-bars consisted of No. 000 copper wire, straightened and fastened with iron staples to the wooden sheathing of the dynamo room without any attempt at insulation, and the switchboard instruments comprised two ponderous pressure indicators, one rudely built ammeter interpolated in the neutral bus to show when the load was out of balance, and half a dozen roughly made plug switches.

In view of all the refinements in electric apparatus which are now deemed necessary for the successful operation of a modern generating plant, it is interesting to look back and consider the crude appliances with which the early central stations were provided.

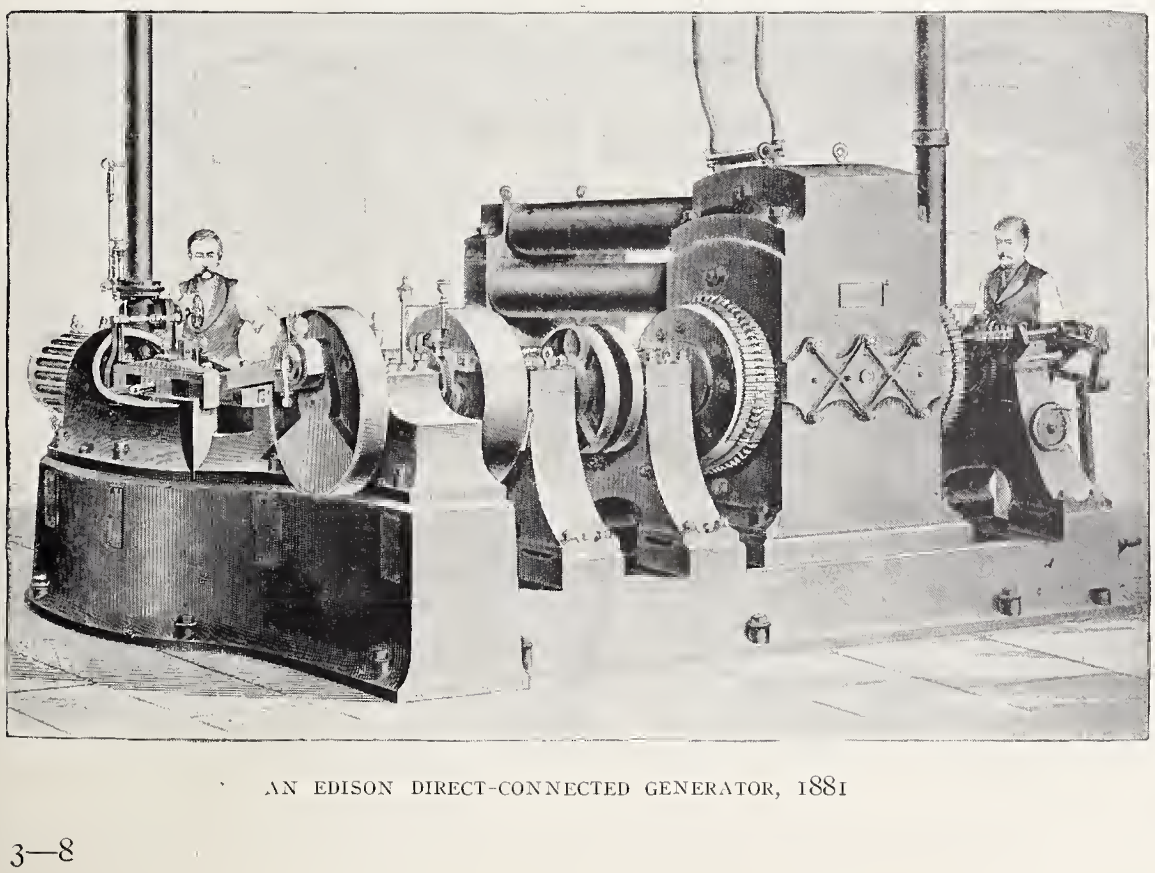


AN EARLY EDISON DYNAMO, 1880

Edison had promised to personally superintend the opening ceremonies, and on July 4, 1883, all preparations being completed, the engine was started an hour or so before sunset; but the dynamos failed to "charge up," and everybody concerned began to feel very anxious.

"Something must have gone wrong on the pole line," said Edison, so all hands started out on a tour of inspection, and not far from the station two feeder wires were found to be "crossed."

This trouble was soon remedied, and fortune now smiled on our efforts. The lamps in the station came steadily up to candle-power, and a general rush was made "downtown." The City Hotel was the largest building that had been wired, and it was found radiant with electric light. Impatient expectation had given place to noisy expressions of wonder and delight among the townspeople who thronged the hotel, and thus was the first Edison three-wire station started.



AN EDISON DIRECT-CONNECTED GENERATOR, 1881

Sunbury was provided with the first electric meters that were used outside of the city of New York. These meters were of the regular Edison type, in which the current is measured by the loss of weight in one of two zinc plates, by electrolytic action. Edison had carefully instructed the meter-man, and firmly impressed him with the belief that the meters were infallible, and that any error in the customers' bills would be a sign of carelessness on his part.

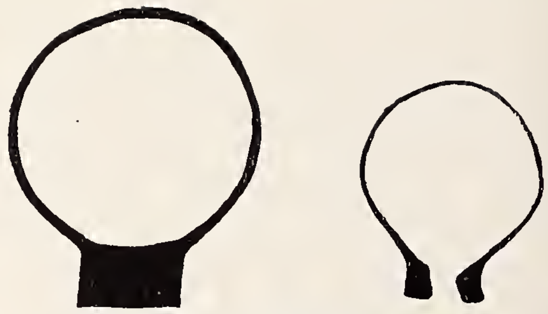
When the first month's bills were made out, most of them appeared fairly reasonable, but two or three showed totals which would have been ruinous to the customer, and the meter-man was considerably exercised. At last he remembered that when putting the bottles containing the zinc plates into these meters, he found that the stiff copper connecting wires were


Manilla Hemp

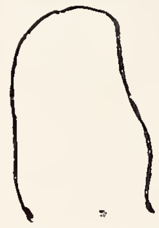

South American Bast

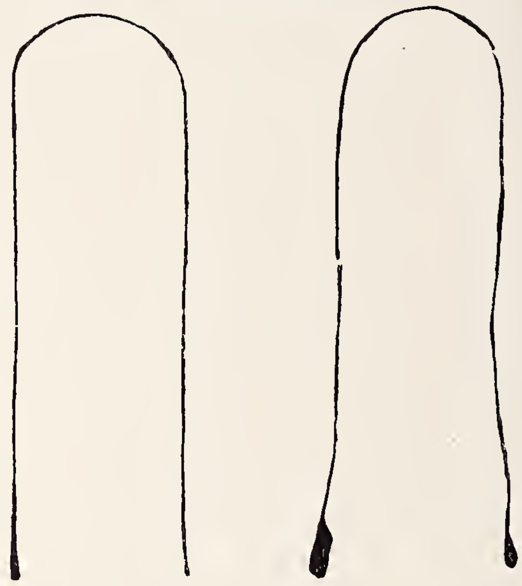

Plumbago Filament

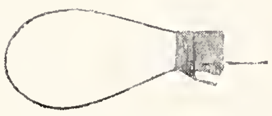

Paper Filament


Cardboard Loop, Before and After Carbonization


Palm Leaf

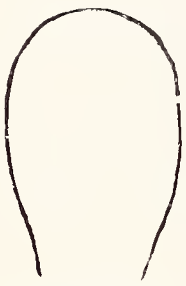

Carbonized Bamboo Thread

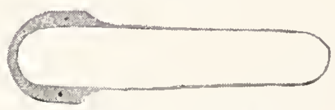

Bamboo Carbons


Brazilian Fibre

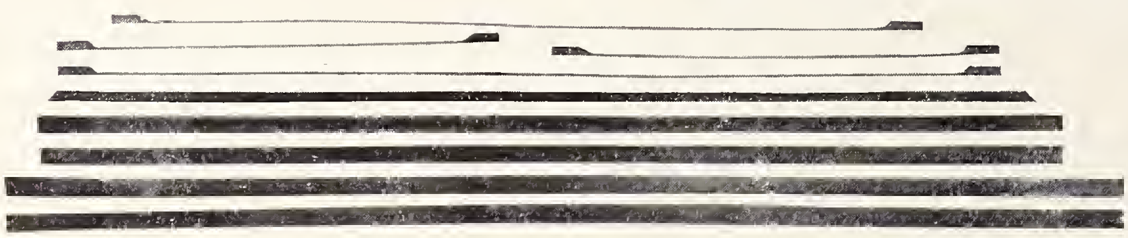

Monkey Bast Fibre

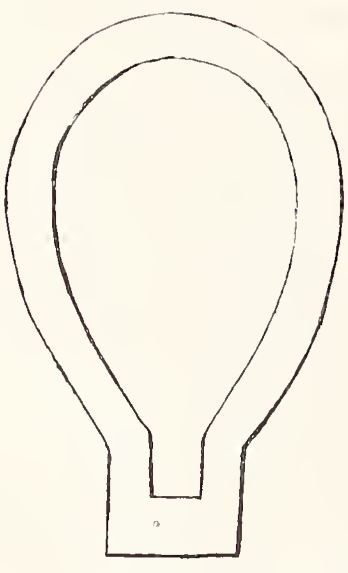

Section of Bamboo

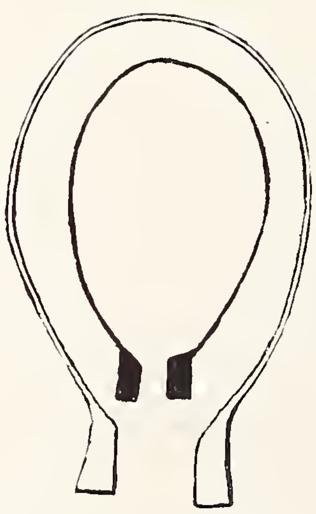

South American Fibre

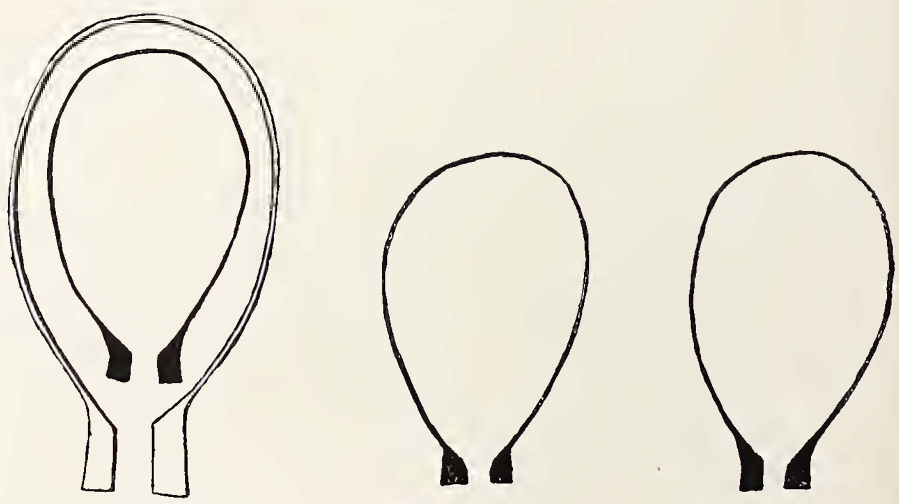

White Wood Cut by Machine


Bamboo Carbons Treated in Hydro-Carbon Vapor


The Various Stages in the Preparation of Bamboo Filaments


Cardboard Loop Before Carbonizing


Bamboo Filaments Before and After Carbonizing


The Old Paper Horse-Shoe, Before and After Carbonizing

REPRODUCTIONS FROM PHOTOGRAPHS OF MATERIALS USED BY EDISON IN HIS EARLY INCANDESCENT LAMP FILAMENT EXPERIMENTS

By Kind Permission of W. J. Jenks

EDISON AND HIS LABORATORY ASSISTANTS AT MENLO PARK, FEBRUARY 22, 1880

a little too long to go into the meter cases, so he cut off short pieces of the wire, forgetting that he had previously weighed the plates and wires together with the utmost care to the tenth of a milligram. In other words, he had cut off pieces of copper wire, the equivalent weight of which in zinc electrolytically removed from one of the meter plates, would have represented a bill of perhaps $100 or more to the customer. He remarked afterwards that those were the most costly pieces of copper wire that he had ever handled!

A short time after the station was started, a heavy thunderstorm passed over Sunbury. Insulating joints for gas fixtures had not been invented, and it was customary to wire up the fixtures by winding flexible cord around the pipes. The writer chanced to be in the office of the City Hotel when the storm was at its height. Suddenly sharp cracks were heard and bright sparks were seen to jump between the wires and the gas fixtures. The hotel guests at once stampeded out into the pouring rain, umbrellas being forgotten in the rush for safety. The writer, however, eventually succeeded in restoring a measure of public confidence by assuring the hotel people that although the building had undoubtedly been struck by lightning, the electric wires had obviously saved it from sustaining serious damage by carrying off the atmospheric electricity to earth through the gas pipes. A few months later another three-wire central station was started at Shamokin, Pa., a coal town about twenty miles from Sunbury. The building was of brick and was much larger and better equipped than the Sunbury station. Three Armington & Sims engines supplied the power, each engine being belted to a separate dynamo. The third or extra machine was installed so that it could be switched on to either side of the three-wire system, as required, thus putting two machines in parallel on that side.

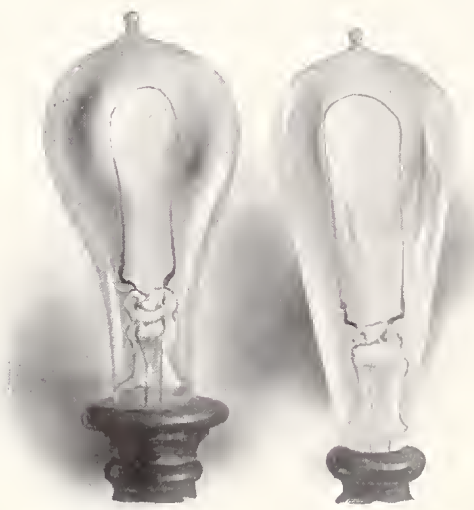
One evening while practicing on the switching-over of the spare dynamo, a little joke was played on the engineer. Two of the machines were running in multiple, each being driven by a separate engine, and the engineer was told to stop one of the engines. He accordingly closed the throttle, but the engine naturally showed no disposition to slacken speed, being then driven by the generator, which ran as a motor, taking current from the other generator.

The engineer gazed at the engine for a few instants, and then tried the valve again, only to find it firmly closed. Still the engine kept on running as if under full steam, and he began to look scared, thinking that some uncanny influence must be at work. After he had puzzled over the situation for a short time, he was informed that in order to stop his engine he would have to open the dynamo switch, which he did with some misgivings as to what might happen

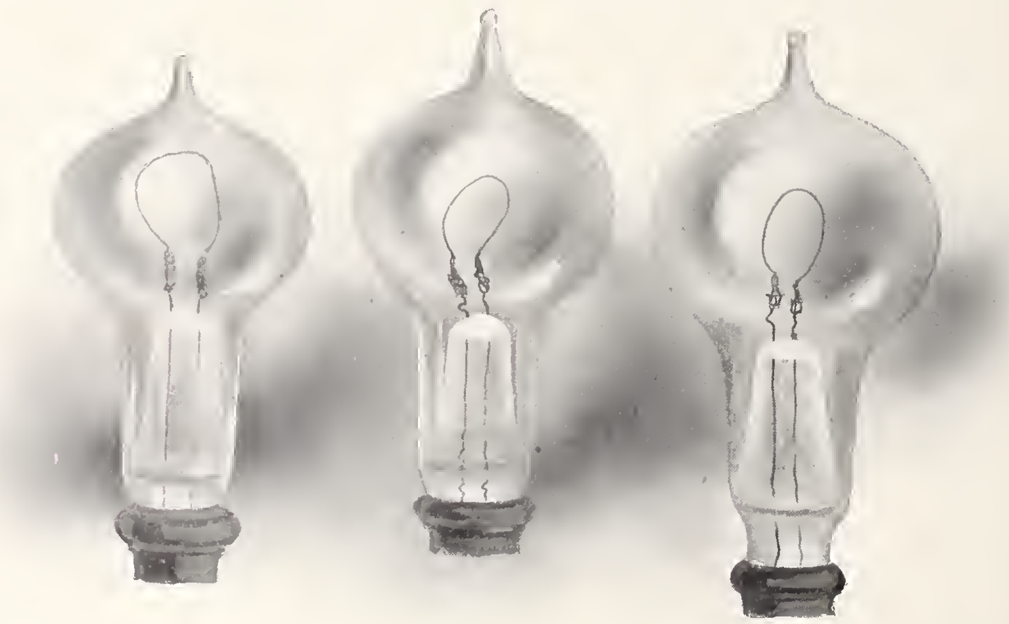
EARLY EDISON LAMPS WITH ROUNDED BULBS. PAPER HORSESHOE FILAMENTS. MADE EARLY IN 1880

A SET OF EIGHT-CANDLE-POWER LAMPS, MADE IN THE WINTER OF 1880. BAMBOO FILAMENTS. THE BUTT OF THE LAMP WAS MADE OF WOOD

AN EXPERIMENT WITH SILVER-PLATED FILAMENT CLAMPS. THE SILVER WAS VOLATILIZED AND DEPOSITED UPON THE INTERIOR OF THE LAMP GLOBES. THESE LAMPS WERE MADE IN JANUARY AND APRIL, 1881

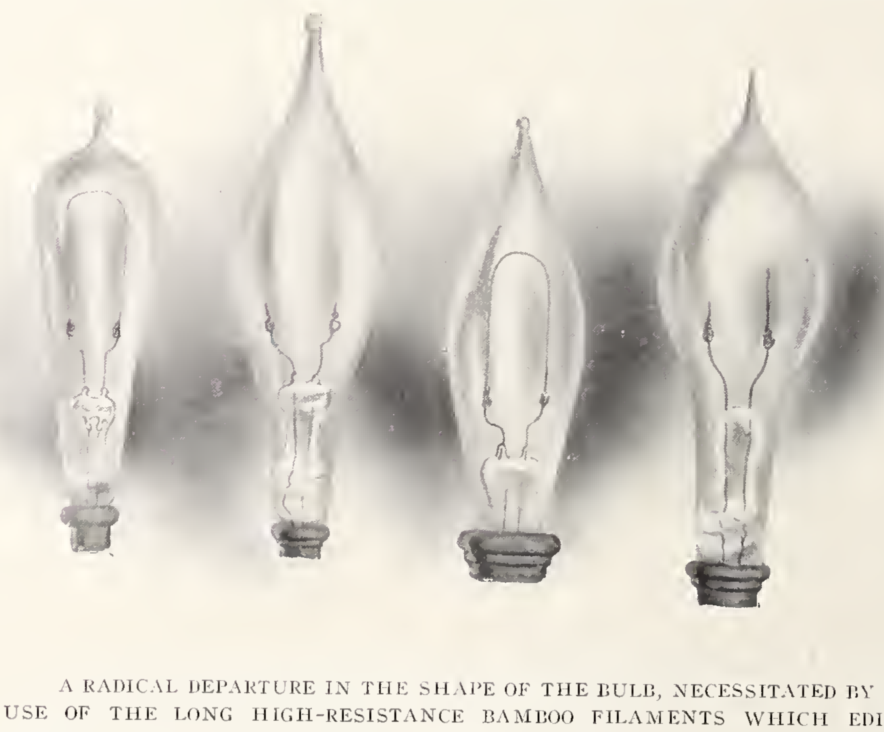


TWO OF THE EARLIEST COPPER-PLATED LAMPS. ATTENTION IS CALLED TO THE VERY HEAVY COPPER DEPOSIT AROUND THE SHANKS OF THE CARBON AND THE LEADING-IN WIRES. MADE IN THE SPRING OF 1881. THE FIRST OF THESE TWO LAMPS LASTED 1589 HOURS AT 16 CANDLES



SOME OTHER LAMPS MADE IN THE SPRING OF 1880. THESE HAD PAPER FILAMENTS

COPPER-PLATED LAMPS WHICH WERE ADOPTED AS STANDARD EARLY IN 1881. THE RIGHT-HAND LAMP IS PRACTICALLY OF MODERN FORM



A RADICAL DEPARTURE IN THE SHAPE OF THE BULB, NECESSITATED BY THE USE OF THE LONG HIGH-RESISTANCE BAMBOO FILAMENTS WHICH EDISON DECIDED TO EMPLOY. THESE LAMPS WERE MADE EARLY IN THE FALL OF 1880

next. He felt relieved, however, when the engine began to slow down and finally stopped; but it was some time before he could understand how the usual process could be reversed and his engine be driven by one of the dynamos.

The lack of proper electric indicating instruments now began to be felt, and the necessity of having an individual ammeter for each generator was emphasized by events which happened a little later at Cumberland, Md. Several armatures had been burnt out in this station without any apparent cause, and the writer was sent thither to investigate the trouble. The generating apparatus consisted of six dynamos, connected three in multiple on each side of the three-wire system.

The station was in charge of a very intelligent colored man, who was both engineer and dynamo tender. On being asked how he distributed his load among the three generators when they were running in multiple, he said:—

"Well, I'm a bit puzzled about that sometimes, but they tell me that the more 'juice' there is going through a wire the hotter it gets, and so I go around and feel the wires leading from the generators to the bus-bars, and try to keep them all about the same temperature, and if one of them gets a little warmer than the others, I turn some resistance into the dynamo."

This explanation showed clearly that the responsibility for the trouble really rested with the people who failed to provide means for indicating the output of each generator, and the facts were reported accordingly to Mr. Edison. Orders were at once issued to make a station ammeter, and the old type of pendulum ammeter was the result. Six of these instruments were first made up for Cumberland station, and after inspecting them, Mr. Edison gave instructions that each ammeter should be packed separately in a strong wooden box. This being done, the six boxes were placed on one of the tables in the testing room, and Mr. Edison then told one of the men to get on the table and kick the boxes off to the floor. Each box received this rough usage several times, and he then had them opened for examination, remarking that if the ammeters would not stand that sort of treatment they were not properly constructed for shipment and subsequent practical service. These instruments were not fitted with jeweled bearings, and they passed the ordeal without injury.

Incandescent lighting was now rapidly becoming a public necessity, and as all three-wire central station plants that had thus far been installed appeared to be financially prosperous, the business expanded very rapidly, and promoters grew rich in the organization of new electric lighting companies.

The limitations of the low-tension three-wire system, however, became apparent, especially in suburban districts where the lighting was scattered and located at some distance from the source of supply, seeing that the cost of conductors made it unprofitable to transmit low-tension current for more than about a mile and a half from the generating station.

About this time the Westinghouse, Thomson-Houston and other electric manufacturing companies began to produce alternating-current generators and transformers and accessory apparatus, their designs being at first largely copied from European models. Later on, Tesla entered the field, and the patents covering his valuable inventions were purchased by the Westinghouse Electric & Manufacturing Company. The acquisition of these patents gave to that company a commanding influence in the industrial application of alternating-current apparatus, and the adaptability and flexibility of the system soon became apparent in connection with the transmission and distribution of current.

Development along these lines was pushed with great energy and skill by the Westinghouse and the Thomson-Houston companies; but for several years progress was hindered by the difficulties which surrounded the coupling of alternating-current generators in multiple, and also for the reason that no alternating-current motors had been developed which could compete in many respects with existing types of continuous-current motors. These and many other drawbacks which handicapped the introduction of the alternating-current system, were gradually diminished or entirely eliminated as new developments were unfolded, and to-day these once rival systems may be seen harnessed side by side, or mutually interchangeable, and, by intelligent handling, producing results which only a few years ago would have been considered impossible.

The writer was recently looking over some extracts from a report of the Washington Bureau of Statistics and noted that the enormous sum of more than $500,000,000 is now invested in this country in central station electric lighting plants. Considering the fact that less than twenty-five years ago, there was not a plant of this kind in existence, we may well be inclined to wonder what will be the future history of such a marvelous industry, which has been growing steadily in this country from its birth at an average rate of over $20,000,000 per annum, and has in the short space of less than twenty-five years attained such magnificent proportions.

In conclusion, it may be stated that about 2,500 Edison incandescent lamps were made at Menlo Park in 1880. Every year thereafter showed a wonderful increase in the number manufactured, and in 1903 the total world's production of Edison lamps has been estimated at 80,000,000.

1.—Thos. A. Edison.	10.—A. Y. Stewart.	19.—A. T. E. Wangemann.	28.—S. G. Burn.
2.—Ch. Batchelor.	11.—W. Miller.	20.—H. J. Hagan.	29.—L. W. Sheldon.
3.—W. S. Mallory.	12.—J. W. Aylesworth.	21.—W. S. Logue.	30.—R. Arnot.
4.—J. F. Randolph.	13.—J. T. Marshall.	22.—Wm. Heise.	31.—C. H. Kaiser.
5.—J. W. Harris.	14.—A. E. Kennelly.	23.—R. Lozier.	32.—J. Martin.
6.—J. Ott.	15.—P. Kenny.	24.—E. W. Thomas.	33.—H. Reed.
7.—Thos. Maguire.	16.—W. K. L. Dickson.	25.—F. P. Ott.	34.—C. M. Dally.
8.—J. W. Gladstone.	17.—T. Banks.	26.—F. A. Phelps, Jr.	35.—F. C. Devonald.
9.—Ch. Brown.	18.—H. F. Miller.	27.—Ch. Wurth.	36.—A. J. Thompson.

EDISON AND HIS ORANGE LARORATORY STAFF, 1893. SEE SUPPLEMENT

Water power to the extent of 238,000 H. P. is used in various French industries.

Fuel Losses in Steam Plants and How to Determine Them

By GEORGE H. BARRUS

Fuel economy in steam plant operation ought to concern the electric station manager quite as much as the purely electric features of his work. There is an intimate relation between the input of coal and the output of electric energy, and the careful control of the former is really at the foundation of a station's successful business; hence, the interest and value of Mr. Barrus' article here. No one knows more about these things than Mr. Barrus, and few have the faculty of setting them forth in as clear and convincing a manner.—THE EDITOR.

FUEL losses in the operation of a steam plant are of two kinds,—one, the direct loss, produced by inefficiency of the boiler, and the other, the indirect loss, due to improper use of the steam for the purpose for which it is intended. The first is confined solely to the apparatus in which the steam is generated, and the problem to which it pertains is centered upon a single object. The second relates to a great variety of subjects, depending upon the uses to which the steam is applied, embracing, as it does, the varied industrial operations for which steam is employed in heating, and the great variety of engines and other motive appliances for which steam is used in the production of power.

The first matter of interest which naturally presents itself in regard to this subject is the question of determining whether or not a steam plant is operating at a loss, and, if so, the extent of the loss; and the second question is what course to pursue in overcoming the loss. In answering the first question we are brought at the outset to the only method of determination available, and that is, a performance test of the plant. By this is meant, in the first place, an efficiency trial of the boiler, and, in the second place, an elementary test which determines the quantity of steam used by each piece of apparatus concerned, whether it be a heating coil, an apparatus using steam for boiling, an engine, or a pump, and the efficiency with which each utilizes the steam supplied to it.

To make an efficiency trial of the boiler is a comparatively simple matter, and it is one about which so much has been said and written that it requires little explanation. It is sufficient, perhaps, to say that by its means the number of pounds of water evaporated per pound of coal is ascertained, and thereby the number of heat units absorbed by the water is determined, which is then compared with the calorific value of the fuel found by the calorimeter test, and the desired efficiency expressed as a percentage or proportion.

It is not so easy to devise methods for measuring the steam used by a number of different pieces of apparatus constituting the plant. Considerable ingenuity is sometimes needed in doing this, depending on the circumstances surrounding each particular case. It may be said in general, however, that the measurements can be made by ascertaining the gross quantity consumed by the entire plant, then dropping off one piece of apparatus and determining the quantity used, then dropping off another and ascertaining the quantity used with two thrown off, then dropping off a third, and so on until data have been obtained regarding the whole number, and finally ascertaining the quantity used by each apparatus by subtracting one total from the next one preceding.

In determining the direct fuel loss at the boiler, assuming a hand-fired furnace, a fairly good efficiency result for ordinary cases may be taken as 75 per cent., that is, the number of heat units actually absorbed by the water evaporated is 75 per cent. of the calorific value, or the total heat of combustion of the fuel. If, by means of the boiler trial, it is found that the efficiency falls below 75 per cent., it may be safe to conclude that the boiler is working at a loss. Taking coal having a calorific value of 14,000 B. T. U. per pound of dry fuel, the efficiency noted applies to an evaporation from and at 212 degrees of 10.87 pounds of water per pound of dry coal. If, therefore, the trial gives a less evaporation with the fuel noted than 10.87 pounds, the indications are, as stated, that the boiler is working at a loss.

Having determined by means of the evaporative test to what extent the boiler is inefficient, the next thing is to locate the cause, or causes, of loss. The most important losses, and those most common, are the losses due to imperfect combustion and to inefficient heating surface. The former is produced by careless handling of the fire and improper admission of air to the furnace, and the latter to faulty arrangement and condition of the heating surfaces. To one who knows by experience the best method of firing any given kind of coal, the character of the combustion can be fairly well judged by viewing the furnace and observing the appearance of the products of combustion and flame issuing from it.

The absolute character of the combustion and the extent to which it is imperfect can be determined only by a chemical analysis of the escaping gases. Such an analysis shows the amount of combustible gas which passes off unburned, and it also shows whether a suitable quantity of air is introduced into the furnace to secure the best results. The analysis, in many cases, proves conclusively whether the method of firing and handling the furnace is the best suited to the fuel used. In the case of a fuel whose characteristics in burning are not well known, it furnishes the best guide available as to how it should be worked. If the efficiency trial shows a low result, other conditions being satisfactory, the gas analysis often provides a means of locating the cause of the loss which, otherwise, it would be difficult to ascertain.

Should it be found from the results of the gas analysis that the quantity of air introduced is too great, it may be due to leakage of air through cracks in the setting, to admission of too large a quantity through the registers in the fire doors, or to the use of too large a percentage of air space in the grate bars. In either case a suitable examination will suggest the proper remedy. If it is found that combustible gas escapes unburned and it is not due to improper firing, it is sometimes caused by the absence of a sufficient quantity of air introduced above the burning fuel. This can often be remedied by simply making perfora-

tions in the fire doors, or enlarging those already provided. The use of a suitable automatic stoker, properly handled, secures the most perfect combustion, and this furnishes a means of improving the efficiency beyond the highest that can be obtained where the furnace is hand-fired.

The inefficiency of the heating surface is revealed by excessive temperature of the escaping gases. In many boilers the temperature would be considered excessive if it exceeded 500 degrees F. There are several causes which lead to high flue temperature. One is the crowding of the boiler beyond its economical capacity, and this is so well recognized as to require little comment.

Another, and one which is widely prevalent, is the unclean condition of the fire side of the surfaces, as also the deposit of scale and sediment on the water side. This is self-evident, but yet it is a matter which does not receive the attention that would naturally be expected. The best remedy for such conditions is the more frequent cleaning of the surfaces, whether external or internal, the use of appliances which prevent smoke and soot, and the adoption of means for purifying the water and preventing the formation of scale. The blowing of the soot and ash from the exterior heating surfaces, after no more than twenty-four hours' run, will frequently cause a drop in the temperature of the escaping gases of 50 degrees. A reduction in the temperature of that amount sometimes causes a saving of 5 per cent. of fuel.

The third reason for inefficiency of surface is improper distribution of the surface in the path of the gases, whereby the gases take a short cut to the flue and leave a considerable portion of the surface untouched. This condition is more apt to occur in water-tube boilers than in fire-tube boilers, and the remedy is the rearrangement of the baffling plates so as to compel the gases to cover the surfaces to their fullest extent.

Whatever the efficiency of the heating surfaces of the boiler, there is a limit beyond which it is impossible to reduce the temperature of the escaping gases, for this cannot go below the temperature of the water in the interior of the boiler. At a pressure of 150 pounds this limiting temperature is 366 degrees F. In any case, however, the temperature can be reduced to a great extent, even to a point below the temperature noted, by the employment of a separate heating appliance placed in the flue and receiving the feed water before it reaches the boiler. Such an appliance, which usually goes by the name of economizer, adds much to the efficiency, especially where there are no waste exhaust steam and hot water returns which can be utilized for the preliminary heating.

There is another kind of efficiency determined by the evaporative test, which may be called the commercial efficiency, and that is the cost, instead of the quantity, of fuel used in evaporating a given amount of water. By making a series of tests, using fuel of widely varying prices, and reducing the results to the cost of fuel required for producing a thousand pounds of steam, taking into consideration the cost of firing and handling the various kinds, determination can be made of the cheapest fuel to use. This kind of test often gives results which are of more value to the owner of the plant than the test which merely determines the efficiency based on the evaporation per pound weight.

Having determined the performance of the boiler and the causes of inefficiency which may be going on in the generation of the steam, the next question is to determine the efficiency with which the steam is used after generation. To make the matter clear and specific, it may be well to assume the purposes for which steam in a given plant is employed. Take, for example, the case of a plant in which the principal parts consist of a compound condensing steam engine, an independent, steam-driven air pump for operating the condenser, a steam-driven boiler feed pump, an auxiliary engine for electric lighting, and a steam heating system embracing a number of heating coils which are drained through a trap. Besides the drainage effected by this trap, the system of steam mains connecting the boilers to the engine and the reheater with which the engine is fitted are also provided with traps. The exhaust steam from the pumps is passed through a feed water heater, from which it escapes to the atmosphere. The quantity of steam used for each of these purposes is ascertained either by the method of differences already mentioned or by some method of direct determination, according as one or the other is best adapted to the situation.

In connection with the test of the main engine, the amount of power developed is ascertained by taking indicator diagrams, and from these is determined the amount of steam consumed per indicated horse power per hour. Whether or not the results thus obtained represent good economy under the conditions of the load which exists, is found by ascertaining from the diagram the weight of "steam accounted for" by the indicator, as it is termed, and comparing it with the actual steam consumption. At ordinary economical loads the difference between the two quantities, when ordinary saturated steam is used and the engine is in good condition, is usually not more than 20 per cent. Should the result of the test show a greater difference than 20 per cent., there is a strong probability that the steam is used wastefully.

One of the most common sources of waste in an engine is leakage of the valves and pistons. If leakage is going on, it can be located by subjecting the various valves and pistons to a leakage test when the engine is at rest, and determining by observation whether the steam blows through. If there are no excessive leakages and the steam consumption per horsepower is still found to be high, revealing thereby a lack of economy, there are a number of causes which may operate in producing this result, and a careful study of the form of the diagram must be made in order to ascertain what these are. Improper setting of the valves which produces a distorted diagram, unsuitable boiler pressure, restricted size of ports and passages, causing loss of pressure during admission and a high back pressure during the exhaust, too early or too late cut-off, and inefficiency in the action of the condenser, may be mentioned as some of the principal causes of waste.

By a similar procedure the economy with which the auxiliary engines and the pumps consume the steam is ascertained, and the causes of loss, whether leakage of valves and pistons or improper setting of the valves or other improper conditions, are located. When the plant is small and the steam pumps connected with it are comparatively unimportant, it is unnecessary to ascertain the amount of power developed by using the indicator. A simple leakage trial is usually sufficient to determine the main source of loss which is likely to occur.

The principal source of loss as regards heating coils, where such are used, lies in the means employed for draining the water condensed and for utilizing the resulting hot water. Where these are so planned or operated that steam escapes uncondensed through the returns, which may be due either to inefficient working of the trap or to waste from the tank into which the return water discharges, such defects call for a remedy. Whether the steam consumed for heating is excessive or not can be ascertained by calculating from the amount of surface heated, the quantity of steam that should be condensed under the circumstances and comparing it with the quantity found on the test. In any case, having determined the quantity

of steam used for this purpose, the question presents itself whether or not the heating cannot be accomplished by exhaust steam derived from the main engine or from the auxiliary engine, and thus economize in the quantity of live steam consumed.

One of the important things shown by the general test of a plant is the efficacy of the feed-water heater. Where exhaust steam is employed, as in the instance cited, and the quantity available is sufficient, the temperature of the water should be raised to a point near 212 degrees. If the temperature is below this point, there is indication that the heater is either too small or that the surfaces are not properly cleaned. If the water is heated to 212 degrees and steam escapes from the heater unused, the steam thus wasted represents a loss. In this case the remedy is to use a portion of the steam for some other purpose. One method which may be mentioned is to employ a boiler feed pump driven by power instead of by steam. Another is to exhaust one or more of the pumps into the receiver of the engine and utilize the steam for power in the low-pressure cylinder.

The data obtained by the test of steam used up in leakage and condensation of the plant sometimes furnish information of the greatest importance in determining losses, the extent of which can hardly be realized without their aid. That part which is represented by condensation in the steam pipes can readily be calculated and allowed for, and the quantity due solely to leakage losses determined. These are the losses produced by leakage of inefficient steam traps which drain the system of piping and reheater, and leakage of stop-valves which cut off the working part of the plant from the heating mains and from parts of the plant that are not in use, to say nothing of the numberless steam joints involved in the construction of the boilers and piping.

In a plant which is working only a part of the day, say ten or twelve hours, the fires being banked the remaining time, these losses, which may be termed the stand-by losses, are continually going on for the entire twenty-four hours, and they represent a larger percentage of the total fuel consumption than they do where the plant is in operation the whole time. Another loss in plants of this kind which is apt to go on while the fires are banked is by no means insignificant. This is the loss of fuel which results from too much draught being on during that time, either from improperly fitted dampers in the smoke pipe, or from carelessness in handling. The flow of air over the bank of fire produces combustion, the heat from which is expended in merely warming the air, which then passes off through the chimney to waste.

There are many losses in the operation of a steam plant which can best be determined by observation, but in general it may be said that there must be a skillful combination of both observation and test along the lines which are here briefly outlined, if all the wastes are to be located and the greatest efficiency obtained from the fuel.

Pertinent Features of the Modern Electric Meter

By H. P. DAVIS, Assistant Chief Engineer of the Westinghouse Electric & Mfg. Co.

From a Paper Read Before the Electric Club of Pittsburg

SPEAKING generally, the best types of induction meters manufactured to-day have reached a high degree of excellence in general design and accuracy. It is now possible to obtain integrating wattmeters having an accuracy equivalent to that found in the best indicating instruments and possessing a range of registration many times greater. If the accuracy of calibration now given to the best types of meters as they leave the manufacturers' testing rooms could be preserved, little else would be desired. Permanency in registration is, therefore, an end toward which every manufacturer is striving; and step by step, the improvements are being made which bring its realization nearer an actual fact.

The causes which preclude permanency in a meter are, first, the aging of the permanent magnets; second, the variations due to changes of voltage, temperature, frequency, etc.; and third, the wear upon the bearings. The first two items should at once be eliminated from consideration, as a meter in which these sources of error exist should receive no more consideration by a station manager than a meter which is not dust, dirt, and insect proof.

The third cause, however, deserves careful and thorough investigation. It is to-day the most vital question before the meter user, because its variable nature produces with extended use a constantly increasing amount of friction in the bearing. A thorough understanding of its causes, as well as the feature of design which produce it, is then of high importance, and especially when it points out the means which can be taken to minimize the effect.

To eliminate friction or to prevent its gradual increase, due to wear and service, is a physical impossibility. Attention must, therefore, be directed towards the incorporation in the moving element, as well as the bearing, of features which will make this wear very slight. Friction will then have as nearly a constant value as possible; and if the friction of the bearing can be made constant, its effect may easily be compensated.

The only source of friction in a well-designed meter occurs between the moving element and its support, and it may be computed by multiplying two factors,—first a constant (the coefficient of friction) which is determined by the nature of the bearings and the condition of the surface; and second, the force with which the surfaces are pressed together. As the first factor, the coefficient of friction depends, with a given form of bearing, on the condition of the surfaces, it is evidently of vital importance that no change take place in them, as otherwise this coefficient will not remain constant. Whatever changes actually occur in meter service are due either to wear or accident, and the amount of change or degree of damage is wholly dependent upon the weight of the moving element. The greater the pressure this exerts, the more rapid the wear of the engaging surfaces, and the more serious the injury occasioned by an accidental blow or jar. As the second factor depends upon the forces with which the surfaces are pressed together, it is obvious that the friction is directly proportional to the weight of the moving element.

The weight of the moving element, and its resulting wear are, therfore, the causes of the variable factor in the meter's permanency. It follows at once, that however well designed a meter may otherwise be, its permanency, when compared with meters of similar design, but with lighter moving parts, will be almost inversely in the ratio of the moving element.

Torque, or turning moment in a meter, is the force doing work which is proportional to the load; theoretically, torque should do no work in the meter except that imposed by the Foucault currents induced in the disk by the permanent magnets. Actually, however, there is another element of work to consider,—friction. To make

its effect as slight as possible, the ratio between friction and the turning moment should be very large, as this ratio enters, in the manner pointed out in the preceding paragraph, as a determining factor in the permanency.

As a matter of fact, this ratio, in practice, can never be made sufficiently large to make the friction effect negligible. Therefore, the second feature, namely, the weight of the moving element, which is the determining factor in meter friction, commands serious attention. Upon it depends not only the initial amount of friction, but also the rate at which this friction will increase the wear.

It is thus apparent that in the consideration of any given ratio between torque and weight, it will be a distinct advantage to have the weight as small as possible. Unfortunately, however, there is a certain minimum, fixed by the amount of material necessary for mechanical strength, below which weight cannot go. In determining this, skillful designing is needed to so adjust the several factors which establish the torque as to obtain the greatest torque value for a certain safe weight. In accomplishing this, the highest ratio is obtained between the pull on the disk and friction.

In considering the first method, lightness of the moving element is of such great importance in establishing permanency that it is not permissible to increase the weight alone, in order to obtain a gain in torque; for not the increase of torque, but a maximum value of the ratio of torque to weight is desired, and increasing the weight alone does not increase this ratio. This procedure, therefore, results in no gain, while it introduces a positive danger, representing proportionately larger friction and greater danger of jewel wear and damage.

The second method,—the only correct and rational one of increasing the ratio of torque to friction,—is that of reducing the friction by use of a light moving element and specially designed bearings. Not only is the ratio increased, but in so doing the cause of wear is minimized and friction values remain more constant.

As already indicated, friction is proportional to the weight of the moving element; yet it is a constant quantity at all speeds. Its effect, therefore, on the accuracy of the meter is to cause it to record too slowly on the light loads. Thus, if the pivot friction amounts to ¼ per cent. of the full load torque, a load of ¼ per cent. will just start the meter; at ½ per cent., the meter will run 50 per cent. slow; at ¼ per cent., 25 per cent. slow; and at 10 per cent. about 2.5 per cent slow, the error decreasing as the load increases, until its effect at larger load is almost eliminated. Suppose, however, the torque at full load is doubled while the friction values remain the same; the result will be that the friction will have but half the effect upon the speed of the meter, and its accuracy will be correspondingly increased.

The claim is often made that a meter having high torque is superior to one having a low torque. This is true only when the high torque is obtained by means of high efficiency in the work magnet which drives the moving element. If the higher torque be secured by increasing the amount of metal in the moving element, no advantage is gained, for the friction is increased in direct proportion. The effect upon the accuracy of the meter is the same as before, while the permanency is greatly reduced, owing to the additional weight and consequent increase in the wear of the pivots as well as the greater danger of accidental injury.

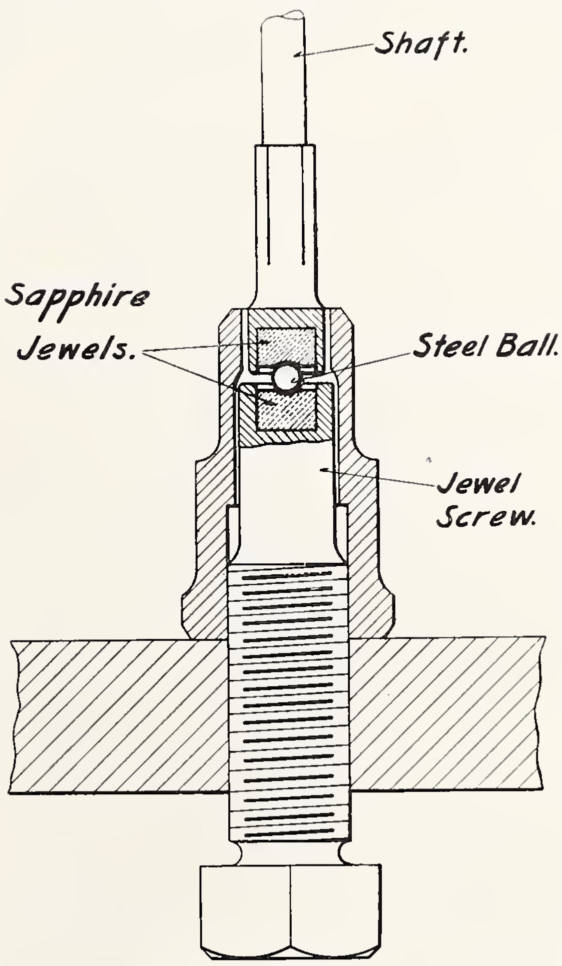


FIG. I.—CUP AND BALL BEARING

From these considerations, it will be seen that the relative proportions of these elements, torque, friction, and weight most vitally affect the accuracy and permanency of the meter. To determine the relative merits and possibilities of different meters, it is very desirable to have a clear understanding of these principles. And from all that has been said it follows that the performance and permanency of meters of similar design, but of equal accuracy when new, can be very closely predetermined by comparing their torque per unit weight of moving element, and bearing in mind that even though they should happen to have equal torque ratios, the meter with the lighter movement is very much to be preferred. These important and vital considerations in meter permanency have been recognized for a long time.

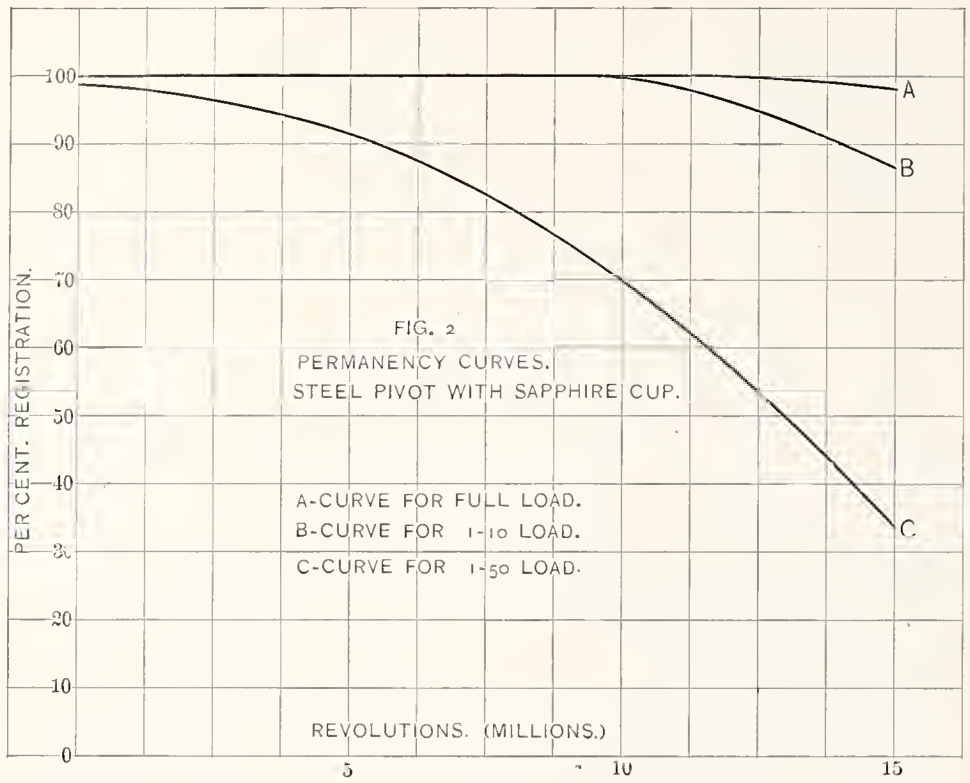
To become thoroughly acquainted with the problem and to obtain data bearing on this subject, an elaborate series of experiments has been carried out in the last few years at the engineering laboratory of the Westinghouse Electric & Manufacturing Company at Pittsburg. In these experiments, every type of bearing commonly used in meters has been very thoroughly investigated and a great amount of data bearing on this subject has been collected. In addition, many modifications of standard forms of bearings have been considered and tested, as well as many other types which promised to be serviceable for meter use.

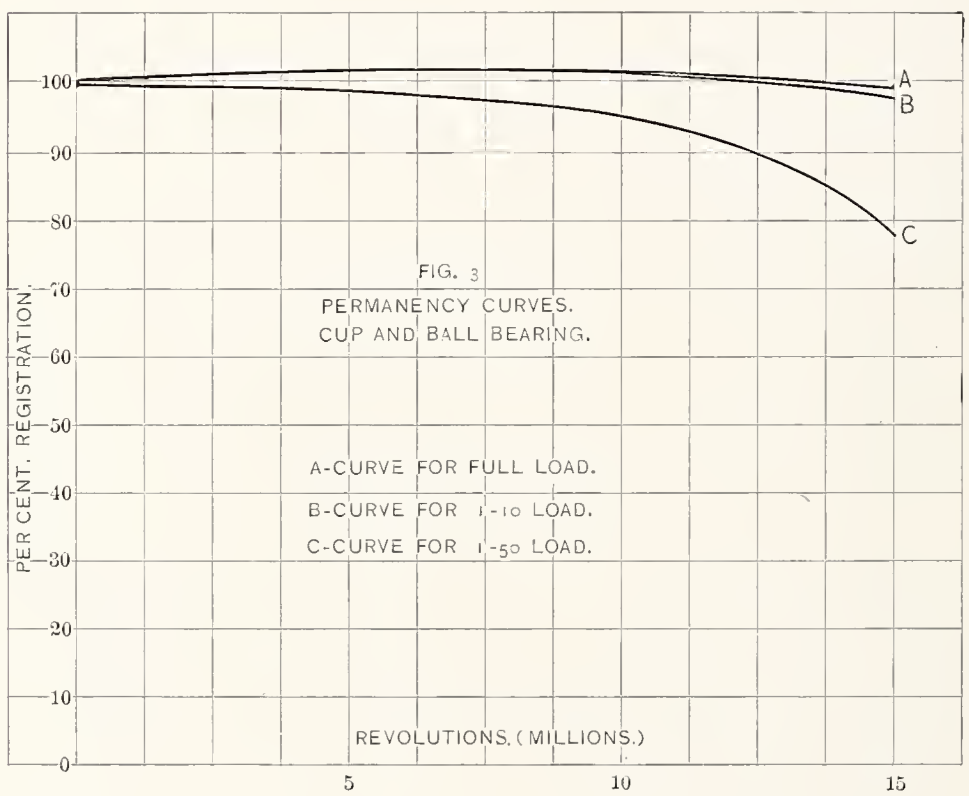
The results of this work have demonstrated, in many ways, the superiority of the so-called cup and ball bearing, illustrated in Fig. 1. In this form of bearing, the end of the shaft and the step present two recesses facing each other, and into each of these is fitted a shallow, hard, sapphire jewel cup. Between the concave spherical surface of these jewel cups is placed a highly polished hardened steel ball, of a less radius than the concave surface of the jewel cups. The moment of friction of this bearing is almost inappreciable, owing to the extreme smallness of the circles of contact of the ball and cups. At the same time the speed of the friction surface is reduced to one-half that of the ordinary meter bearing; the ball, rotating at one-half the speed of the shaft, is also subject to less wear. Further than this, whatever wear occurs is evenly distributed over the entire surface of the steel ball. Vibration merely causes a rolling motion on the ball, instead of a running one. Moreover, if one jewel is accidentally injured to such an extent as to prevent rotation between itself and the ball, the bearing of the meter is still as good as the ordinary pivot form.

When the superior features of this type of bearings were fully recognized, a series of experiments was undertaken to determine the best relations between the jewel and the ball. After this had been determined a number of wattmeters were built with this form of bearing. A similar number of wattmeters with the standard form of bearing were also selected, and special

care was taken to have the bearings of all as carefully and accurately made as possible.

These meters, all of the same capacity, were carefully calibrated and adjusted, and all were connected to measure the same load and so arranged that they would run continu-





ously on this load at full speed. This test was conducted without interruption for one year, during which time the meters were stopped only at stated intervals to check their calibration. During this time they made over fourteen million revolutions. To duplicate this run in actual service would require from four to six years.

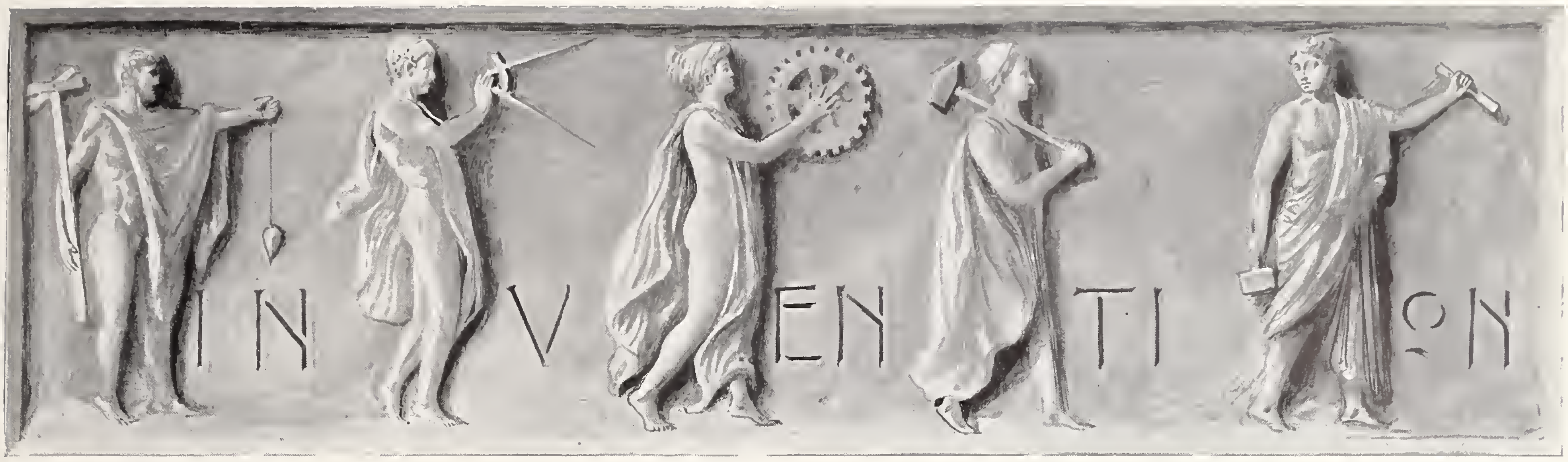
In Figs. 2 and 3, the results of this test for one-fiftieth load, one-tenth load and full load are shown graphically. It will be noted in the curves *A* and *B*, that with either form of bearing, the wear was not sufficient to affect the accuracy until the meters had made ten million revolutions, when the meters having the regular pivot bearings commenced to slow down slightly on full load and quite rapidly on one-tenth load. On the other hand, the accuracy of the meters with cup and ball bearings had not been affected by wear at full load even up to fifteen million revolutions and only very slightly at one-tenth load.

On the lighter loads, however, the wide difference in the amount of wear in the two types of bearings is most marked. Referring to Figs. 2 and 3, the curve *C*, in which the effect at one-fiftieth load is plotted after ten million revolutions, which would be an equivalent of at least three years' service in the ordinary residence, the average speeds of the meters with standard forms of bearings dropped 30 per cent., while the average slowing down of the meters with cup and ball bearings is only 5 per cent.

This remarkable performance shows conclusively how slight the wear and resulting friction is with this form of bearing. As a matter of fact, the meters with this new bearing indicated a permanency on one-hundredth load which was as good as on the one-fiftieth load. From this time on the wear became more apparent with both forms of bearings. At the end of a year of continuous operation, when the meters had all made fifteen million revolutions, the meters with regular bearings had slowed down 68 per cent. on one-fiftieth load and 8½ per cent. on one-tenth load, while the cup and ball bearing was 22 per cent. slow on one-fiftieth load, but only a little more than 1 per cent. slow on one-tenth load. In conducting this test, great care was taken to duplicate as closely as possible actual operating conditions.

Experiments have shown that the well-known phenomenon of the speaking arc lamp is not confined to the electric arc lamp, but that the Bunsen and other similar lamps are capable of reproducing speech under conditions practically similar to those employed in the case of the electric arc, one terminal of the secondary of the usual induction coil being introduced into the flame, the other attached to the metallic burner of the lamp. The primary of the induction coil is in series with a battery and a microphone transmitter, which is placed some distance from the flame. When the transmitter is spoken into the voice is clearly reproduced by the flame.

The filament in glass lamps gradually diminishes in diameter in consequence of the slow volatilization of the carbon. According to the "Elektrotechnische Rundschau," of Berlin, a German firm introduces into the glass globe certain chemical compounds with a high boiling point; these, under the influence of the temperature in the lamp bulb, slowly give off vapors containing carbon which is deposited on the filament, thus making up, to a large extent, for the loss caused by the volatilization referred to. Besides it is claimed to keep the resistance and the brightness of the lamp more uniform throughout its useful life.



Electrical and Mechanical Progress

The Largest Steam Turbine Electric Unit

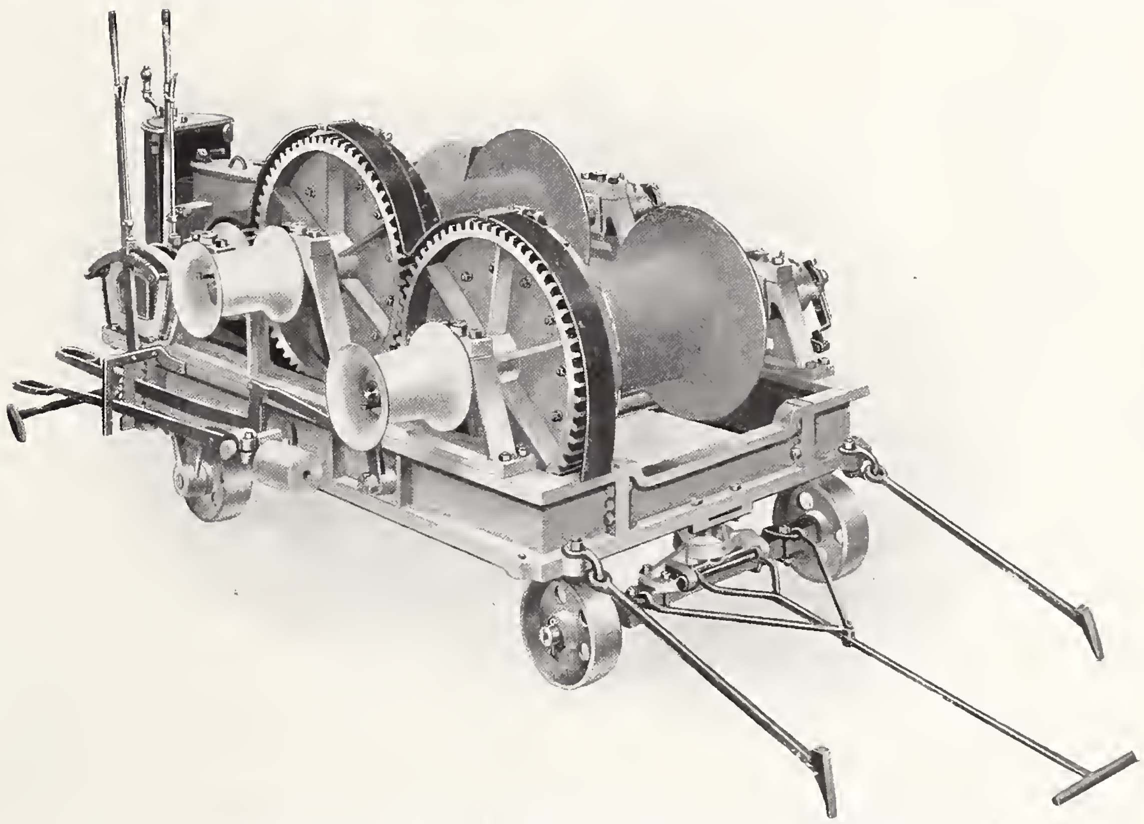
WHAT will be the largest steam turbine-driven unit which has been built so far, will probably be the one for which the Essen, Germany, electric central station has recently given an order to Messrs. Brown, Boveri & Company, of Baden, Switzerland. It will consist of a steam turbine direct-coupled both to a 5,000 kw., 5,000-volt, three-phase alternator, and a 1,500 kw., 600-volt, direct-current generator. The combined output of these two generators will absorb about 10,000 horse-power, measured at the turbine shaft.

The completed unit will be about 60 feet long; the height and width will be less than 10 feet. The turbine itself will be about 23 feet long. The unit will be so arranged that each individual part can be attended to from the engine-room floor, thus obviating the necessity for men running up and down several floors, as is the case with vertical reciprocating engines or turbines. As regards the efficiency of this enormous group, it is guaranteed that the steam consumption per kilowatt-hour will be less than $15\frac{1}{2}$ pounds. This figure corresponds to a steam consumption of about 9 pounds per indicated horse-power per hour.

A Portable Electric Hoist

IN addition to the illustrations of electric hoists given in the article on "Electric Motor-Driven Hoists and Derricks," elsewhere in this issue, attention is here directed to a special form of portable electric hoist made by the Lidgerwood Manufacturing Company, of New York.

It is a double-friction-drum direct-current hoist, with winch heads on the drum shafts, mounted on dock wheels. Eye bolts and dogs are furnished if desired, to be driven into convenient places to hold the machine stationary. The general design of the outfit is well shown in the illustration on this page, and its convenience for dock service can be readily appreciated.



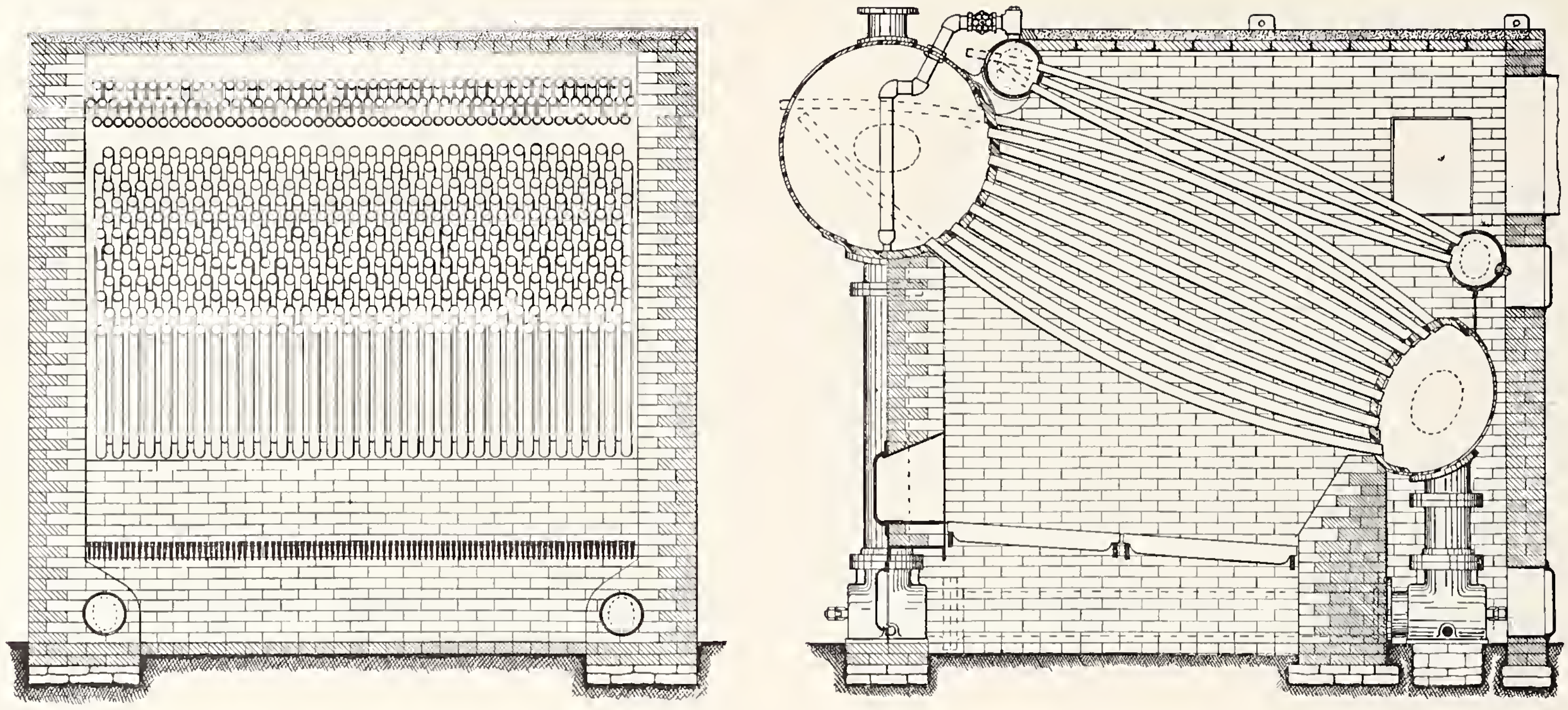
A PORTABLE ELECTRIC DOUBLE-DRUM HOIST, MADE BY THE LIDGERWOOD MFG. CO., NEW YORK

The Mosher Boiler

THE Mosher water-tube boiler, which has become well known in marine practice, is now being exploited for stationary service as well as for electric central station work for example, by its makers, the Mosher Water-Tube Boiler Company, of New York.

It may not be amiss, therefore, to call attention anew to its characteristics with the help of the illustrations on this page. The boiler is made up essentially of a steam and a water drum, tubes connecting the two drums, and a circulating pipe. The steam drum is supported at each end by the circulating pipe which conducts the water from the drum under the grate to the water drum, which it supports at the back of this grate. The heads of both drums are provided with manholes.

The regular tubes connecting the drums are arranged in vertical rows of



THE MOSHER WATER-TUBE BOILER FOR STATIONARY SERVICE. MADE BY THE MOSHER WATER-TUBE BOILER COMPANY, NEW YORK

six each, staggered and placed so close together that each tube acts as a baffle for the tubes below it, helping to distribute the gases over the entire surface of the tubes and sweeping them clear of all ashes and soot. No baffle plates are used, and all angles and corners liable to collect dust and soot are avoided as much as possible. The tubes are accessible for cleaning and removal by a row of handholes in the front of the steam drum, the curvature of the tubes being such as to admit of their being readily taken out. Five vertical rows of six tubes each are accessible from each hole.

The handholes are closed by a special plug or cover which consist

THESE DIAGRAMS ILLUSTRATE WHY SOME BOILER TUBES BECOME COVERED WITH SOOT AND ASHES AND REMAIN SO, AND ALSO WHY THE TUBES OF THE MOSHER BOILER ARE KEPT CLEAR

of a conical-headed bolt provided with a short piece of copper tube, a washer and nut. The head of the bolt and copper tube may be inserted in the handhole from the outside of the drum, after which the nut may be screwed up, thereby flaring the end of the copper tube by drawing the conical head of the bolt into the same, thus forming a steamtight metallic joint, the pressure always being on the head of the bolt, thereby increasing the tightness of the joint.

One of the features of the Mosher boiler is to be found in an economizer which is incorporated in it. This feed heater consists of two water drums into which are expanded slightly curved tubes, accessible for cleaning and removal in much the same manner as those of the boiler proper. It is placed above the boiler, intercepting the gases on their way to the flue. The drums of the feed-water heater are out of the path of the gases of combustion, thus making it impossible to injure them, regardless of the amount of scale or sediment that may collect in them.

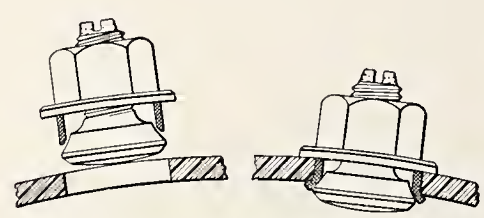
The water first enters the lower drum of the feed-water heater and passes through the heater tubes to the steam drum of the boiler, whence it passes through the circulating pipes to the water drum and thence into the tube system where it is evaporated. The tubes have a steep inclination which, in a measure, prevents the steam from clinging to them in bubbles or collecting in small angles or pockets. The steam drum provides ample room for the storage of steam.

The boiler is constructed in standard sizes up to 2,500 square feet of heating surface and in larger sizes to meet any special requirements. The standard boilers are fitted with cast-iron grate bars, but wrought iron bars may be fitted when required for special service.

A 1,500 Horse-Power Motor Starter

PROBABLY the largest motor-starting rheostat ever constructed was recently built by the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., and a very good idea of its design may be had from the cuts on the next page. It is to be used in starting a 1,500 horse-power, 500-volt motor at frequent intervals under full load, and on account of the unusual capacity of the installation, the following description of the apparatus may be of interest.

In design the starter is similar to the well-known Cutler-Hammer multiple-switch type, having a plurality of switch levers, mounted on a slate panel, each switch lever being used for cutting out a portion of the resistance. In the present case nine toggle-joint switches are employed, supported by a horizontal steel rod and free to swing thereon. Each switch is similar to a circuit-breaker with the tripping-coil omitted, being provided with a laminated leaf main contact, an auxiliary copper bar contact, and a renewable carbon block, which makes contact with another carbon block on closing the switch before the main brush makes contact, and upon opening leaves the carbon block after the main contact, thus



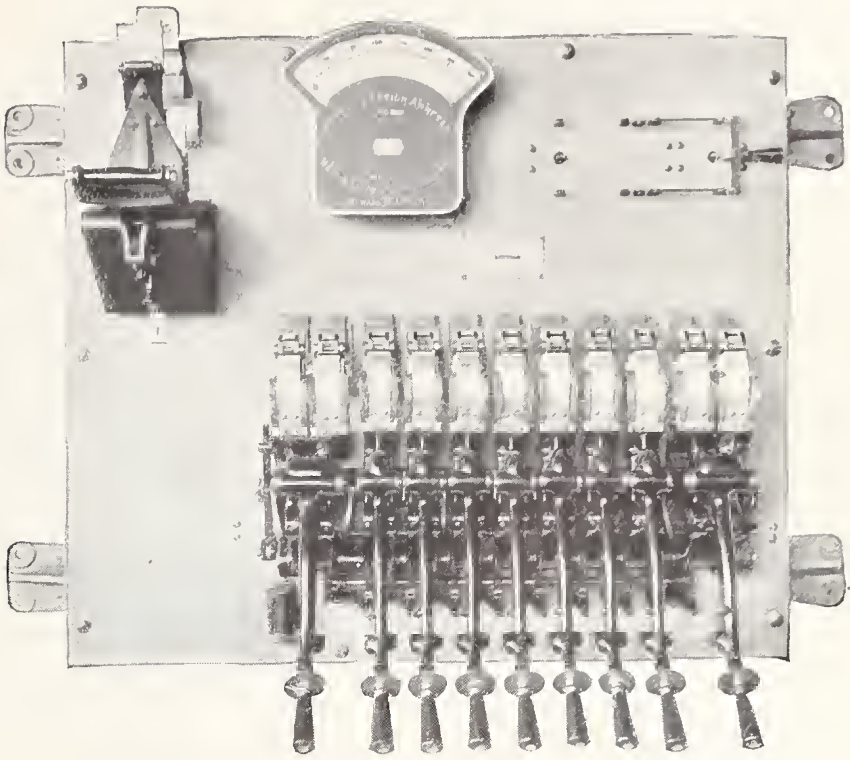
THE HAND-HOLE PLUGS OF THE MOSHER BOILER

taking any arc that would be formed should the operator partially close the switch and then open it again.

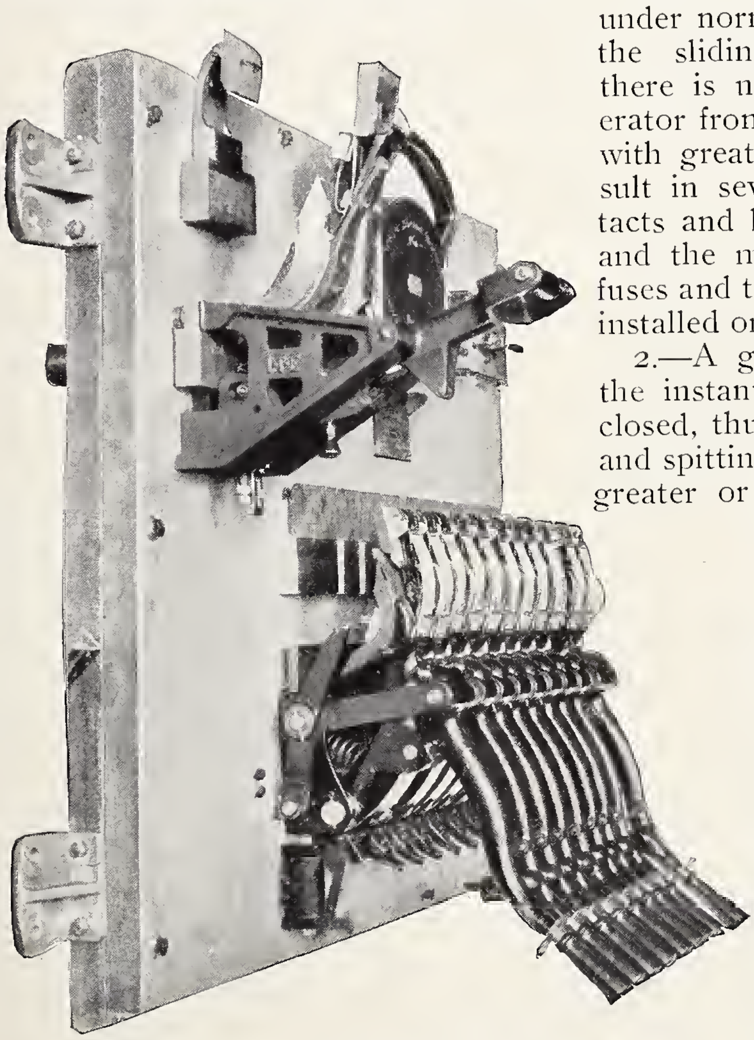
Each switch is held in its full closed position by a steel catch, which hooks over the edge of a cast-iron dog pivoted to the switchboard in front of each switch. This arrangement forms a mechanical interlock, so that when the first switch is closed, it lifts the dog in front of the second switch, permitting this switch to be closed, which

then lifts the dog in front of the third switch, and so on until all the switches are closed in their proper order. The first switch is held closed by a steel catch hooking over a soft iron armature, attracted by a small retaining magnet, consuming about 10 watts of energy. When the supply of current is shut off, this magnet becomes deenergized and releases the first switch, thereby opening the motor circuit, and as the first switch flies open, it allows the dog in front of the second switch to drop, and thus releases the catch which holds the second switch closed. This second switch then flies open and releases the third switch in a like manner, and so on until all the switches are open. Every switch lever is thus automatically returned to the starting position as soon as the current supply is interrupted.

In building starters of very large capacity, it is the practice of the Cutler-Hammer Manufacturing Company to utilize iron pipe for the starting resistance, carrying off the heat developed by the current in the pipe by connecting the latter with a water supply. The closing of the first switch opens a valve mounted on the back of the switchboard, and thereby admits water to the pipe resistance. When the last switch is closed, it closes another valve which connects the pipe resistance with the sewer or drain pipe. When the supply of current is shut off, the first lever flies open and recloses the water admission valve, and the last lever also flies open and reopens the water exhaust valve, so that all mechanism is automatically put in position for another start.



A 1,500-H. P. MOTOR-STARTING RHEOSTAT, MADE BY THE CUTLER-HAMMER MFG. CO., MILWAUKEE, WIS.



A SIDE VIEW OF THE CUTLER-HAMMER LARGE RHEOSTAT

The advantages claimed for the multiple - switch type of motor starter, as compared with the ordinary form of starting box employing a single lever moving over a large number of contacts, may be briefly enumerated as follows:

1.—It is practically impossible for the operator in cutting out the starting resistance to close the numerous switches with sufficient rapidity to cause the flow of abnormal currents under normal load conditions. With the sliding-contact type, however, there is nothing to prevent the operator from moving the starting lever with great rapidity, which would result in severe sparking on the contacts and brushes of both the starter and the motor, and the blowing of fuses and throwing of circuit-breakers installed on the line.

2.—A good, firm contact is made the instant any one of the levers is closed, thus eliminating the sparking and spitting which always occurs to a greater or less extent in starting a loaded motor with the sliding-contact type of starter.

3.—Since with the multiple-switch type there is absolutely no sparking on its contacts when cutting out the starting resistance, it becomes practical to greatly reduce the number of resistance steps used. The sliding-contact type, on the contrary, must be provided with a constantly increasing number of steps as the motors increase in size, not for the purpose of more smoothly accelerating the motor, but for the sole purpose of reducing the sparking which occurs when moving a sliding contact from one segment to the next. A large number of segments are for a similar reason necessary in a commutator, not for the purpose of reducing the pulsations of current or voltage, but only to reduce sparking as the various armature windings are cut in and out of circuit. For all practical purposes a motor can be accelerated under load just as smoothly with ten steps of starting resistance as with a hundred, and it is, moreover, immaterial whether the mottor be of 10 horse-power or 1,000 horse-power.

4.—While it would be possible to construct a sliding-contact type starter for, say, a 1,500 horse-power motor, the apparatus would necessary be of such large size as to require a small motor to turn the rheostat lever, and would be come practically a commercial monstrosity. Large motors are usually started, by those who do not employ the multiple-switch type of starter, by means of very large drum controllers, which not only cost a great deal more, but contain none of the advantages enumerated above, and also lose the protection afforded by the automatic no-voltage release feature.

In the past three years the Cutler-Hammer Manufacturing Company have manufactured a large number of multiple-switch starters of various sizes, made under basic patents granted to H. H. Cutler. These starters are carried in stock complete in sizes from 10 100 horse-power, and larger sizes up to 2,000 horse-power are assembled from standard parts kept on hand at all times.

Three hundred thousand incandescent electric lamps, so it is said, will be used in lighting the St. Louis Exposition buildings.

Standard Size Trade Catalogues

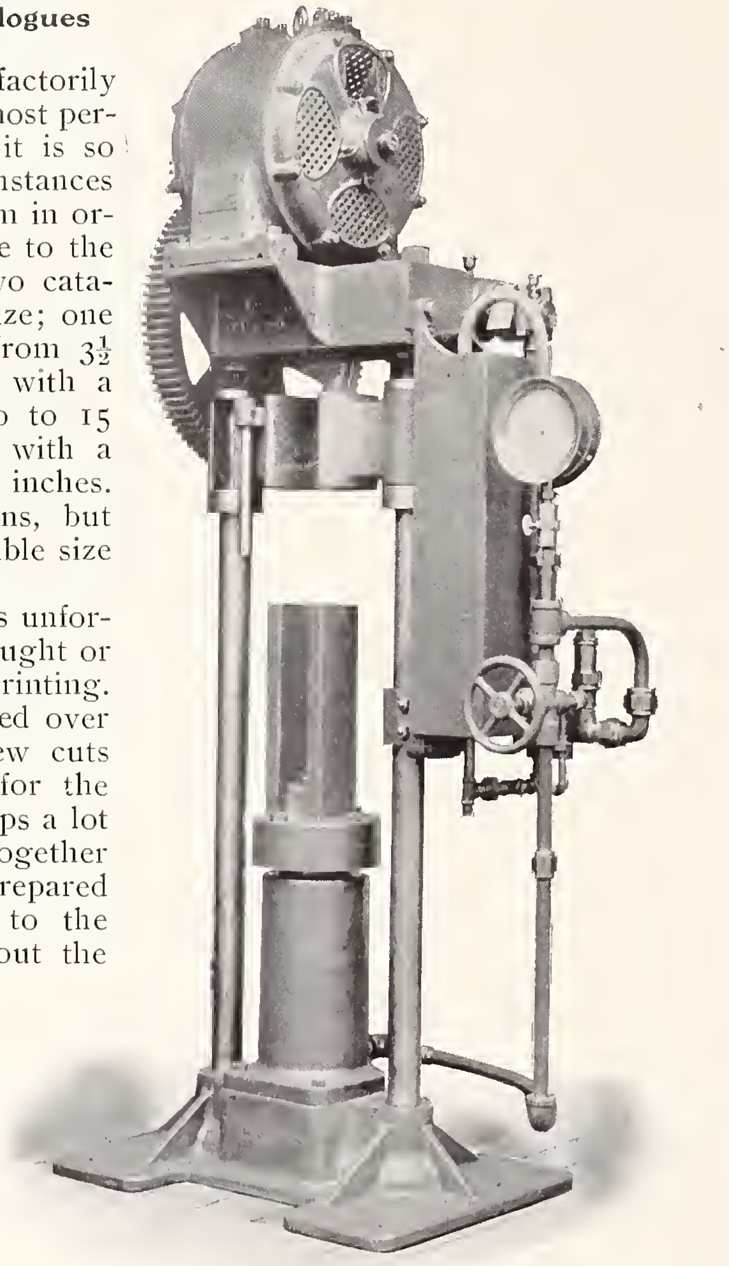
THE problem of satisfactorily filing catalogues is a most perplexing one; in fact, it is so difficult that in very many instances no effort is made to keep them in order. In large part this is due to the fact that it is rare to find two catalogues of exactly the same size; one may find them of any size from $3\frac{1}{2}$ inches on the binding edge with a length of a foot or more up to 15 inches on the binding edge with a length of $3\frac{1}{2}$ inches to 20 inches. These are extreme dimensions, but they exist, as does every possible size within the limits named.

The principal reason for this unfortunate condition is lack of thought or attention in preparation and printing. Many times the work is turned over to inexperienced persons; new cuts are ordered without regard for the conditions to be met, or perhaps a lot of engravings are gathered together and, with rough and poorly prepared manuscript, are hurried off to the printer, who is told to get out the catalogue. The matter of size is probably left to the latter, or at most, the desired dimensions are given only approximately. A definite specification for the paper stock to be used may be given, but more likely it is not; hence, the printer may conclude to work up some paper he has on hand, and the size of the catalogue is made to fit the stock. Thus arises the multitude of sizes that exist.

There is no more reason for these "misfit" catalogues than there is for bad work in any other direction. The manufacturer is the loser, and if the facts could be ascertained the figures, representing the cost of literature almost thrown away by reason of the difficulties of filing, would certainly be startling.

Steam railroad officials were the first to recognize these difficulties, and approximately ten years ago took up the question of standardizing both literature and stationery. The sizes which were recommended by their committee were as follows:—Letter paper, $8\frac{1}{2}'' \times 11''$; memoranda, $8\frac{1}{2}'' \times 5\frac{1}{2}''$; catalogues, $3\frac{1}{2}'' \times 6''$, $6'' \times 9''$, and $9'' \times 12''$; index cards, $3'' \times 5''$, and $4'' \times 6''$. These sizes have become standards with them and with many outside of the railroad field; files are provided for the preservation of literature and stationery that conform to the sizes given. Catalogues and pamphlets of other dimensions are preserved only when necessity demands it.

Printers have become so accustomed to cutting only approximately to size that they are not likely to understand that if 9 x 6 inches are specified, that size is actually meant. The catalogue is more likely to be cut to $8\frac{3}{4}'' \times 6\frac{1}{4}''$, or some other approximate dimension. Unless, therefore, it is distinctly understood that the dimensions ordered must be delivered, or the work will be rejected, the man who orders the catalogue will not get what he wants. This it is well to bear in mind in getting ready for new trade literature.



AN ELECTRICALLY-DRIVEN ARMATURE PRESS, MADE THE WATSON-STILLMAN COMPANY, NEW YORK.

A Hydro-Electric Armature Press

THE 30-ton armature press shown in the illustration on this page, and made by the Watson-Stillman Company, New York, represents an interesting combination of motive powers,—hydraulic and electric, the electric motor, shown mounted on the top of the machine, driving the pump which supplies the pressure water for the hydraulic ram.

The upper beam revolves upon ball bearings to permit of its being easily pushed out of the way to allow of the armature being built up or more discs being put on the shaft without removing it from the press. The motor is one made by the Westinghouse Electric & Manufacturing Company.

It has a 4" rawhide pinion on the armature shaft meshing with a cut gear, 24" by 3" in diameter. This is upon the pump shaft. The pump has a piston $\frac{3}{4}''$ in diameter and is double acting. The press ram has a motion of 9". The distance between rods is $15\frac{1}{2}''$. The removable "U" block is 18" high and its top 9" from the lower side of the swinging beam. The jaw of the beam and the block are large enough to permit of the pressing of work on a 3" shaft.

The press, complete as shown, weighs 2,200 pounds, including the motor.

The Relative Fire Risk of Oil and Air Blast Transformers

By E. W. RICE, Technical Director of the General Electric Co.

A Paper Read Before the American Institute of Electrical Engineers.

TWO types of transformers have been extensively used in electrical installations up to date, distinguished by the method of insulation and cooling employed. The "oil transformer" relies upon oil as the cooling and insulating fluid. The "air-blast transformer" contains insulation material mainly of cloth, paper, and wood impregnated with oil or varnish, and is cooled by the circulation of a blast of air. In both types the insulating material is of an inflammable nature and under certain abnormal conditions may take fire with more or less serious consequences.

The electrical engineer must, therefore, consider carefully not only the relative but the actual fire-hazard which exists, and by proper and common sense methods minimize such danger. Both types can be made entirely safe by correct methods of design and installation.

I think it will be admitted that in general that type which contains the

greater quantity of inflammable material will occasion the greater fire-hazard. The inflammable material in an air-blast transformer of say 1,000 K.W. capacity will amount to about 800 pounds; in an oil-cooled transformer of the same capacity the amount will be about 7,300 pounds. While this comparison cannot be taken as a measure of the relative fire-risk, it is an indication to be considered, especially in view of the fluidity, the low temperature of ignition, and high calorific value of oil.

While the quantity of inflammable material in an air-blast transformer is, as stated, relatively small, it has an extended surface exposed to a large volume of air, and therefore, if a fire starts from internal causes, such as short-circuit or extreme overload, is capable of rapid combustion. This combustion could be checked by shutting off the flow of air to a transformer by means of a diaphragm automatically closed by the melting of a fusible link, the fusible link so located as to be melted by the first contact with flame,—a method similar to that employed for closing fire doors in buildings.

An oil-transformer, properly cooled, is probably not particularly subject to ignition of the oil from internal burn-outs or arcs. It is well-known that oil is an excellent medium for the smothering of alternating arcs, and this principle is utilzed in connection with oil-switches.

The vapor above the oil may, however, be ignited by electrical discharges. Even in this case, while the quantity of combustible material is enormous, the surface exposed is relatively small. The principal fire-hazard in an oil transformer is due to the large mass of inflammable liquid material which under certain conditions may become totally consumed. It becomes a special hazard in the case of fire from sources external to itself.

Considerations of first cost, economy of space, simplicity, operating costs, etc., have resulted in placing transformers in the same room with switchboards and other apparatus, such as synchronous converters, motor-generators, etc. Under such conditions, it would seem that the air-blast transformer constituted the lesser fire-risk than the oil transformer, and would therefore be generally employed if the fire-risk were the only consideration. The air-blast type, however, is limited in practice to pressures of about 30,000 to 35,000, as the static discharge which occurs at much higher pressures would in time break down the insulation. It is therefore necessary to employ oil insulation on the higher pressures now common.

The fire-risk can be practically eliminated by placing such transformers in a room or rooms separated by suitable fire walls from the other part of the plant. This plan has already been proposed and introduced. An entirely separate building, subdivided again into suitable rooms, may be employed where the maximum of safety is demanded. Much may be done to limit the risk, even when the transformers are placed in the same room with other apparatus, by proper systems of piping for drainage of the oil away from the building, by placing the transformers in a depressed area of concrete arranged for rapid drainage, etc. Of course, any of the methods commonly employed for preventing, limiting, or extinguishing oil fires may properly be employed.

A discussion of this subject is both timely and important. It is well for engineers to consider carefully the dangers of all kinds, both to life and to property, that may exist in connection with the use of electrical appliances. The art is not advanced by ignoring or belittling the existence of real difficulties, but rather by intelligently facing the problems which occur and seeking a proper solution. Electrical energy is capable of being produced, handled, and transmitted more safely than any other form of energy, and such dangers as exist usually can be foreseen and safe remedies can be applied. On the other hand, we must not exaggerate the danger of fire from the use of transformers of either the oil or air-blast type. I believe the fire-hazard is extremely small, and can be and is being reduced to a negligible quantity by the adoption of methods similar to those I have outlined here.

It is announced that formative plans are now under way to conduct an unusual celebration commemorating the opening of the New York rapid transit subway some time in June of the present year. Invitations will be extended to the President of the United States, Cabinet officers, Supreme Court justices and others connected with the national government. Governor Odell, of New York, and the Governors of other States and Mayors of leading cities of this country and the principal cities of Europe will also be invited. Addresses will be delivered both by statesmen and the heads of the company undertaking the work.

The next meeting of the National Electric Light Association will be held at Boston on May 24, 25 and 26.

Changes in the Allis-Chalmers Company's Business

ONE of the most interesting business announcements of the month has been the one to the effect that President Charles Allis, of the Allis-Chalmers Company, of Chicago, the largest machinery manufacturers in this country, has resigned and will retire from the active management of the business and that the company has entered into an agreement with the Bullock Electric Manufacturing Company, of Cincinnati, whereby the business of the two companies will hereafter be carried on as that of a single interest. In connection with the Bullock Company's affairs, Joseph S. Neave, vice-president of the company, is quoted as follows:—

"The present Bullock Electric Manufacturing Company will remain intact. The same officers will be continued, and also the same management. The old company is incorporated according to the laws of New Jersey. There will be another Bullock Electric Manufacturing Company formed according to the laws of Ohio. This will be the leasing company of the plant, and this company will run the Bullock plant as it is run at the present time. In fact, the Bullock Electric Manufacturing Company and the Allis-Chalmers plants will be run as if they were one concern. The Allis-Chalmers Company guarantees to pay the 6 per cent. dividend on the preferred stock of the Bullock Company. It goes further; the Allis-Chalmers Company agrees to pay 6 per cent. on the common stock of the old Bullock Electric Manufacturing Company for all the assets of the Bullock Electric Company that are over and above the valuation of the preferred stock.

"As an explanation of the payment of dividends for the common on the quick assets of the company, it might be stated that the preferred stock of the present Bullock Company amounts to $1,100,000, and the common to $1,000,000. Thus, after the valuation of the plant has covered the preferred stock and there should be, for instance, $500,000 of what is termed quick assets over, the Allis-Chalmers Company guarantees, during the life of the lease, 6 per cent. on this amount for the Bullock common stock.

"Besides the payment of these dividends," continued Mr. Neave, "the Allis-Chalmers Company agrees to divide the profits of the concern between the new company and the common stock of the old company. This will tend to make the earning power

B. H. WARREN, THE NEW PRESIDENT OF THE ALLIS-CHALMERS COMPANY, CHICAGO

of the common stock of the old company a great deal more than it is at the present time.

"As a result of this deal with the Allis-Chalmers Company, the present capacity of the Bullock electrical works is to be enlarged. The first thing that will be done will be to erect another large shop, with an area of 40,000 sq. ft., where motors for street cars will be manufactured. This will mean the employment of about 400 more hands. It is the intention of the new leasing company to enter actively into the street car equipment field. The lease is for twenty-five years with the privilege of renewal for another twenty-five years on the same terms. It is my opinion that when the plants that are now under way have been completed, the Bullock electrical works will give employment to from 2,000 to 3,000 hands."

The Allis-Chalmers Company announce further that they have completed arrangements for the manufacture of steam turbines, hydraulic machinery, gas engines and electrical machinery, in addition to its regular line of big machinery, for which it has acquired a world-wide reputation. The company has become associated with and forms part of the Steam Turbine Advisory Syndicate, of England, which is composed of the Yarrow Shipbuilding Company, the Tweedie

E. D. ADAMS

(Vulcan) Shipbuilding Company, and Messrs. Willans & Robinson. Mr. Fullager, formerly chief engineer of the Parsons Steam Turbine Company, of England, is now the consulting engineer of the Steam Turbine Advisory Syndicate. The Allis-Chalmers Company's license from the syndicate concedes to it the rights to build the steam turbine in the United States, Canada and Mexico, with equal rights and privileges in South America and elsewhere in the Western Hemisphere.

The steam turbine which the Allis-Chalmers Company will make is a horizontal one,—of the Parsons type. The company has also concluded arrangements with Messrs. Escher, Wyss & Co., of Zürich, Switzerland, whereby it becomes the sole American licensee for that firm's hydraulic machinery. The American patents for the gas engines of the Nürnberg Machine Company, of Nürnberg, Germany, have also been acquired by the Allis-Chalmers Company, as previously announced in these columns, so that the company will be prepared to furnish engines of that type of any required horse-power.

The Allis-Chalmers Company as it exists to-day comprises the following well-known manufacturing concerns:—The E. P. Allis Company, of Milwaukee, Wis.; the Fraser & Chalmers Company, of Chicago; the Gates Iron Works, of Chicago; the Dickson Manufacturing Company, of Scranton, Pa. In addition to reciprocating engines, hoisting engines, pumping engines, compressors, steam turbines, water turbines, mining machinery, crushers and cement machinery, the Allis-Chalmers Company are the largest makers of saw mill machinery and flour mill machinery, together with their accessories.

The Western plants of the Allis-Chalmers Company are located in Chicago and Milwaukee, the latter comprising two large plants employing about forty-five hundred men, where reciprocating engines, hoisting engines, turbines, flour mill machinery and saw mill machinery are manufactured. The two plants in Chicago are devoted to the manufacturing of mining, crushing and cement machinery, employing eighteen hundred men; the works in Scranton, Pa., are devoted to the manufacture of coal mining machinery, sugar machinery, water turbines and hydraulic machinery, employing upwards of eight hundred men.

The new president of the Allis-Chalmers Company is Mr. B. H. Warren, well known in the electrical field from his connection, as vice-president, with the Westinghouse Electric & Manufacturing Company. His brother, Mr. Arthur Warren, until recently manager of the Westinghouse Companies' publishing department, will organize and be in charge of the Allis-Chalmers Company's publicity bureau, and Mr. Asa M. Mattice will be the chief engineer of the company, having, to that end, resigned his position as chief engineer of the Westinghouse Electric & Manufacturing Company, to take effect on April 1.

Mr. Edward D. Adams, the banker, who has been identified with the company since its organization a few years ago, will be the chairman of the ex-

ARTHUR WARREN

ecutive committee, this step involving the abolition of some of the previously existing committees and the concentration of a great deal of responsibility and power in his hands. Mr. Adams will, in fact, make his offices at the New York headquarters in the Empire Building and give a large amount of his time to Allis-Chalmers affairs.

Personal

Thomas A. Edison has gone on one of his flying trips to Fort Myers, in Florida, to remain until early in April. The species of relaxation which Mr. Edison seeks at his Southern retreat may be gauged to some extent by the fact that one of the adjuncts to his establishment there is a miniature edition of his laboratory at Orange, N. J., in which he finds a necessary and agreeable outlet for his restless energy.

Aeroplanes formed the subject of some interesting remarks by Dr. Elihu Thomson at the recent dinner given in honor of Professor S. P. Langley by John Brisben Walker. Dr. Thomson thought that the ideal machine for flying was necessarily a species of kite which, instead of having a string to hold it up in the air,

would be pushed through the air by means of propellers somewhat after the manner followed in Professor Langley's aerodrome and other simi-

ELIHU THOMSON

lar machines; hence the necessity for further development in producing an engine of minimum weight per unit of power output. It is interesting to note here that Professor Langley is said to have succeeded in obtaining an engine weighing between four and five pounds to the horse-power.

G. P. Altenberg, manager of the foreign department of the J. A. Fay & Egan Company, Cincinnati, the largest manufacturers of wood-working machinery in the world, has left for Europe. He will first visit England, and after a few weeks' sojourn there will tour the Continent. He expects to remain abroad for several months. While in Paris Mr. Altenberg will make his headquarters at 31 Boulevard Haussmann.

G. P. ALTENBERG

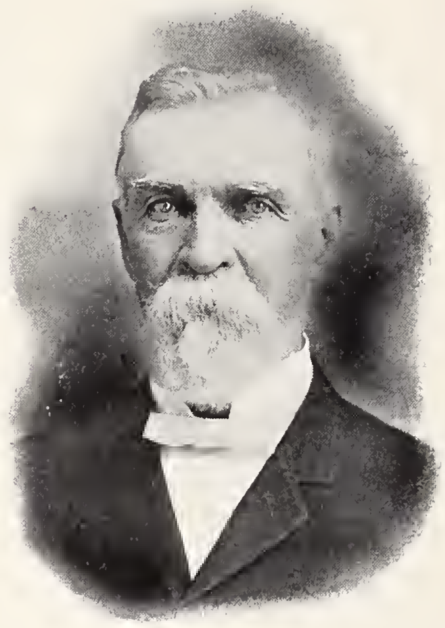
At the recent annual meeting of the Engineers' Club, of Philadelphia, Carl Hering was elected to the presidency for the year 1904. This flourishing society was organized over twenty years ago and includes among its members practically all the engineers in and around Philadelphia. It is the only engineering society of that city. Mr. Hering has been a member of it for over twenty-two years, and during most of this time he has taken an active part in its meetings. This is the first time in the history of that society that the presidency has been tendered to an electrical engineer. Several years ago Mr. Hering was president of the American Institute of Electrical Engineers. He is the delegate for this country of the International Society of Electricians, whose headquarters are in Paris, and has received two decorations from the French Government for his services as member of the jury at the Paris Exposition of 1899 and 1900.

CARL HERING

The Allis-Chalmers Company having bought, as mentioned elsewhere, the good will and experience of Messrs. Escher, Wyss & Co., of Zürich, Switzerland, for the construction of all kinds of hydraulic turbines to be built to order, and to meet the precise needs of each particular case, having placed their resulting hydraulic department in charge of Clemens Herschel, well known in water-power work in the United States. The turbines are to be built at the Scranton, Pa., shops of the Allis - Chalmers Company and their hydraulic power department will be at the company's New York offices.

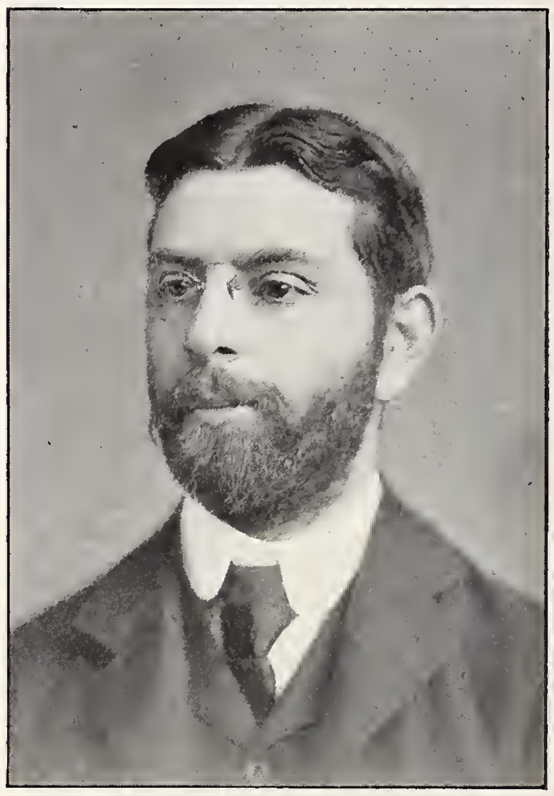
CLEMENS HERSCHEL

John Fritz, of Bethlehem, Pa., Bessemer medalist and honorary member of the Iron and Steel Institute, is president of the American reception committee which is preparing for the coming meeting of the institute in this country in October of this year. An executive committee has been organized, of which C. Kirchhoff, of New York, is chairman, the other members being Robert E. Jennings, the treasurer, and Theodore Dwight, the secretary. Bennett H. Brough, the secretary of the Iron and Steel Institute, has issued a list of those members who have signified their intention to come to America. From this is appears that the gathering will be a very large and representative one. Mr. Fritz was one of the distinguished guests at the dinner given to Thomas A. Edison at the Waldorf-Astoria on February 11, by the American Institute of Electrican Engineers.



JOHN FRITZ

In the recent consolidation of the Allis-Chalmers and the Bullock Electric Manufacturing Company interests the services of Mr. B. A. Behrend have been retained as chief electrical engineer of the Bullock Company. Mr. Behrend is a member of the American Institute of Electrical Engineers, a member of the Committee on Standardization, and chairman of the local branch of the Institute at Cincinnati. He is also a fellow of the American Association for the Advancement of Science, and has been appointed a member of the advisory



B. A. BEHREND

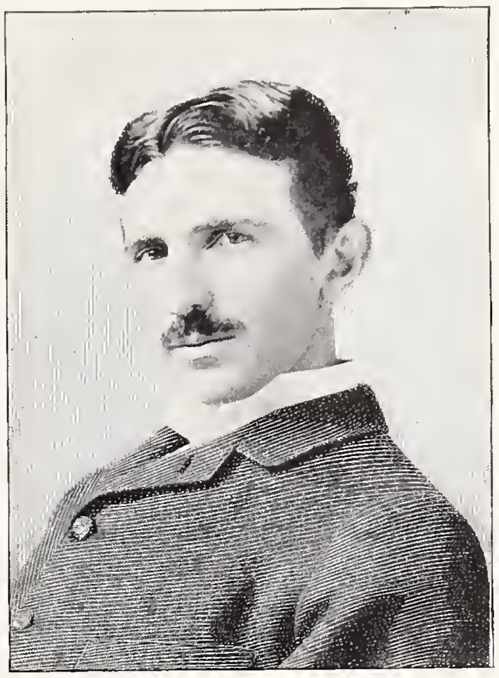
committee of the International Electrical Congress, to be held at St. Louis in September of this year. He has written an exhaustive treatise on "The Induction Motor," which has already been translated into French and German, and has lectured at the universities of Leland Stanford, McGill and Wisconsin. Mr. Behrend's successful work during the past four years in the design of several hundred thousand kilowatts of large alternating and direct-current machines, has helped to establish the engineering reputation of the Bullock Company as a factor in the building of electric power plants of the largest size. Among Mr. Behrend's more notable designs are the municipal plant at Nashville, Tenn.; 5,000-kw. of alternating-current generators in Denver, Col.; five 5,000-kw. generators for the Kern River Power Company, California; the generators for the Pacific Electric Railway Company, Los Angeles; the generators for the Mutual Electric Company, San Francisco; the frequency changers in Montreal, representing 10,000 kw., and numerous other plants of note and interest. The 3,500-kw. generating unit which will be exhibited by the Allis-Chalmers and Bullock Companies at the St. Louis Fair, the largest power unit at the Exposition, was also designed by Mr. Behrend.

W. A. BRACKENRIDGE

Vice-President W. B. Rankine, of the Niagara Falls Power Company, recently announced the appointment of A. Howell Van Cleve as resident engineer of that company and its allied companies, to fill the vacancy caused by the resignation of William A. Brackenridge, who has recently been appointed to the Advisory Canal Board by Governor Odell. Mr. Van Cleve has been connected with the engineer corps of the Niagara Falls Power Company continuously since April, 1892, and at the time of his appointment as resident engineer to succeed Mr. Brackenridge he occupied the position of assistant engineer.

A. H. VAN CLEVE

Nikola Tesla has issued an announcement to the effect that with the commercial introduction of his inventions he will render professional services in the general capacity of consulting electrician and engineer. The near future, he expects with confidence, will be a witness of revolutionary de-

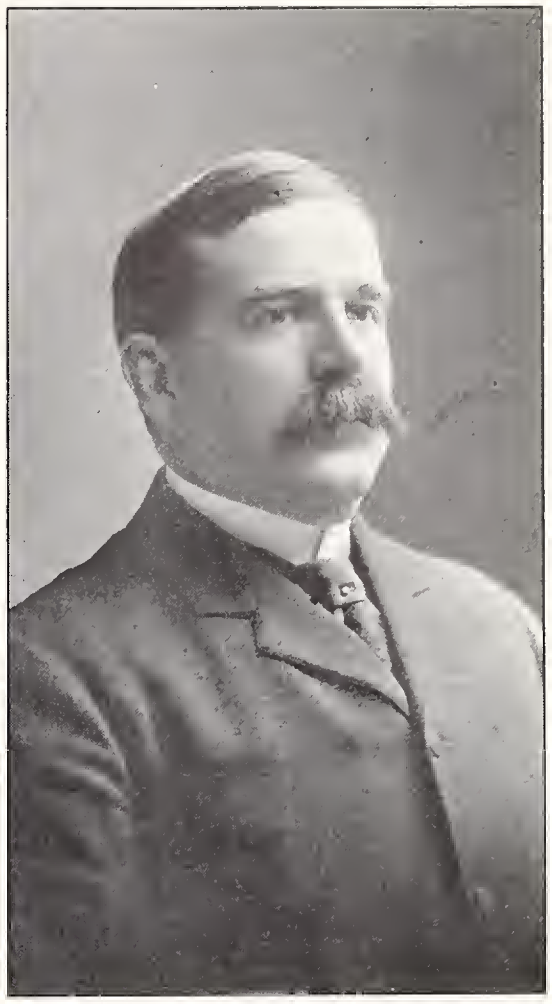


NIKOLA TESLA

partures in the production, transformation and transmission of energy, transportation, lighting, manufacture of chemical compounds, telegraphy, telephony and other arts and industries. In his opinion, these advances are certain to follow from the universal adoption of high-potential and high-frequency currents and novel regenerative processes of refrigeration to very low temperatures. Much of the old apparatus will have to be improved, and much of the new developed, and he believes that while furthering his own inventions, he will be more helpful in this evolution by placing at the disposal of others the knowledge and experience he has gained. He will give special attention to the solution of problems requiring both expert information and inventive resource. He will undertake the experimental investigation and perfection of ideas, methods and appliances, the devising of useful expedients and, in particular, the design and construction of machinery for the attainment of desired results.

An interesting lecture on "Electricity from the Waterfall" was delivered recently by Dr. F. A. C. Perrine, of the Stanley Electric Manufacturing Company, of Pittsfield, Mass., before the Lynn General Electric Engineering Society, of Lynn, Mass.

W. D. Baldwin, president of the Otis Elevator Company, New York, has returned from a trip to Europe, whither he recently went in connection with the contract for the large passenger lifts to be installed in the London underground railroad system now being constructed by the Charles T. Yerkes syndicate.



W. D. BALDWIN

Carl Schwartz on March 1 entered the electric department of the New York Central & Hudson River Railroad Company as assistant engineer in charge of the department for the electrical equipment of the traction power stations for the electric operation of the system. For about a year and a half previous Mr. Schwartz was connected with the Commonwealth Electric Company, of Chicago, where he was in charge of the design of the new Fisk street station of that company, laid out for Curtis steam turbine generators of 5,000 kw. each. There he had opportunity to introduce a number of new features in the work of the station which promise to be successful in high-tension power station work. In Chicago he was further in charge of the erection of several new sub-stations for 1,000 kw. rotary converters and a high-tension distributing system designed by him.

CARL SCHWARTZ

Mr. Schwartz received his engineering education at the Royal Technical College in Hanover, and from there entered the works of the Allgemeine Elektricitäts-Gesellschaft, of Berlin, as designing engineer. Later he joined the Siemens & Halske Company, of the light and power department of which, in St. Petersburg, he became chief engineer.

Philetus W. Gates and Henry W. Hoyt, respectively general superintendent and second vice-president of the Allis-Chalmers Company, have retired from active participation in the management of that company. Mr. Gates was president and Mr. Hoyt secretary and general manager of the Gates Iron Works for fifteen years prior to the incorporation of the Allis-Chalmers Company in 1901. They have been prominently connected with the manufacturing interests of Chicago and have taken an active part in all of the manufacturers' associations. The late P. W. Gates—the father of Philetus W. Gates—was the pioneer manufacturer of Chicago and the region west of the Alleghenies, having established his business in 1842. From 1861 to 1781 the Eagle Works Manufacturing Company, of which he was president, employed about one thousand men, and in those days was a noteworthy industry. In 1871 the Eagle Works Manufacturing Company went out of existence, and from it were organized the Gates Iron Works and Fraser & Chalmers, each of which took a portion of the business of the old Eagle Company. Both of these companies in turn were taken over by the Allis-Chalmers Company in 1901. Messrs. Hoyt and Gates, after a vacation spent in traveling, will re-engage in business in Chicago.

P. W. GATES

H. W. HOYT

Gen. Francis V. Greene, general manager of the Ontario Power Company, spoke before the Niagara Club, at Niagara Falls, on the evening of March 4, on "The Future of the Niagara Frontier." He predicted that the improvement of the Erie Canal would mean a wonderful upbuilding of that section and the restoration of the Empire State to the supremacy in the industrial world, and that cheap power, generated at the falls, proximity to raw material and railroad and lake transportation advantages will result in the establishment on the Niagara frontier of large industries in steel and iron electrochemical products, milling and various textile lines.

Putnam A. Bates, assistant secretary and sales manager of the Crocker-Wheeler Company, resigned his position on March 1. Mr. Bates has formed a partnership with John Neilson, who was until recently assistant secretary and assistant treasurer of the New York & Stamford Electric Railway. Under the firm name of Bates & Neilson the partners will conduct a general practice of consulting electrical engineering, with offices in New York City.

W. B. Potter, head of the railway department of the General Electric Company, has sailed for the West Indies, in search of health and warmer weather. He has been struggling for some weeks past with incipient grip and pneumonia, but would not let go until the doctors and his associates insisted he must break away or pay the penalty.

Trade News

The Nernst Lamp Company has appointed G. E. Bennett district sales manager of their Buffalo district office, recently established at 17 West Mohawk street. These quarters will include an office, showroom, exhibition room, and stock room, with a complete stock of lamps and supplies to meet the requirements of the trade in this territory. The company recently closed contracts for the installation of 165 Nernst lamps in the Washington National Bank Building and 75 lamps for the Pittsburg Supply Company, at Pittsburg, Pa. They have also succeeded in securing the adoption of Nernst lamps by the municipal electric light plant of Silverton, Col., in competition with enclosed arc lamps.

The William Tod Company, Youngstown, Ohio, builders of Corliss and medium-speed engines for all electrical work in lighting and railway plants, etc., have recently opened an office at 29 Broadway, New York, with George T. Woolston in charge.

The Turbine Engineering Company, engineers and contractors for complete water power plants, has established offices at Chicago, Ill., New York, N. Y., and Troy, N. Y. The hydraulic power department is at West Troy, N. Y. The company is prepared to take complete contracts covering the entire installation of water power plants, acting in the double capacity of engineers and contractors, making a single contract and giving a single guarantee covering efficiency and economy of the entire installation. The officers are A. M. Young, president; H. G. Runkle, vice-president; M. J. Warner, treasurer; F. A. Curtiss, secretary; L. G. Read, general manager; G. Sturgess, manager hydraulic power department. The company is sole agent for the Sturgess water-wheel governors, which will be furnished either alone or combined with water-wheels by the best builders of self-governing units.

The Quincy Engine Works, Quincy, Ill., builders of special machinery as well as of the Williams vertical engines, the Quincy Corliss engines and the Quincy four-plunger motor-driven pumps, have just completed a set of ten special filter presses for a large glucose factory, together with an electric motor-driven four-plunger hydraulic pump and hydraulic accumulator for operating it.

The Ball Engine Company, of Erie, Pa., has received a contract from the Eastman Kodak Company, Rochester, N. Y., for two 400 horse-power vertical cross-compound engines, to be direct-connected to a 250 kw. Crocker-Wheeler generator. The Ball Company has just installed two 350 horse-power vertical cross-compound, direct-connected units in the First National Bank Building, Chicago, and is also building two additional units of the same size for this plant.

Queen & Company, Inc., of Philadelphia, have issued a handsome and instructive circular celebrating the fifty years of their existence, 1853-1903. It gives a synopsis of the history of the house, illustrates some of its leading apparatus, etc., and gives views also of its laboratories, factories, etc.

The Safety Insulated Wire & Cable Company, 114 Liberty street, New York, has been requisitioned by the Japanese Government for a large lot of torpedo cable. A contract has been secured from the Philippine civil government for 30 miles of standard type cable which will be used to connect the last of the numerous islands with the mainland. The company has taken contracts from the same source which will represent in all nearly 2,000 miles of cable. The

United States War Department has ordered a big quantity of range-finder cable for use in different fortifications along the Atlantic, Pacific and Gulf coasts.

The British Thomson-Houston Company, Limited, of Rugby, England, which is controlled by the General Electric Company of this country, has received the contract from the Underground Electric Railways Company for the electric motor equipment to be used in the extensive underground electric traction system of London. This contract, which calls for 480 cars each equipped with 500 horse-power in motors, will, it is understood, together with the balance of the equipment, amount to $7,000,000. The contract for the passenger elevators which will be used at the stations of the underground system has been awarded to the Otis Elevator Company, of London and New York, and amounts to about $1,750,000,—the largest contract for passenger elevators which has ever been placed in this country or abroad. The underground stations will be fitted in most cases with four, and in some cases with six elevators, each capable of raising a load of 10,000 pounds, equivalent to about 65 passengers, at a speed of 200 feet per minute, the shafts varying from 40 to 180 feet in depth. Charles T. Yerkes, formerly of Chicago, is the chairman of the Underground Electric Railway Company, in which American interests are largely concerned. Of the $85,000,000 which will be expended by the Underground Company in its improvements, $40,000,000 are American capital.

Shoshone Falls, 25 miles south of the city of Shoshone, Idaho, are about to be utilized for power purposes by their owner, Senator A. W. Clark. The diversion of the waters will be effected by means of a tunnel 2,200 feet in length, the headgate of which will be located 600 feet above the falls. From the end of the tunnel to the power house the water will come down in 8 iron pipes, each pipe 9 feet in diameter. These pipes will drop 210 feet to twin horizontal turbines coupled direct to the electric generators. Eact generator will furnish 5,000 horse-power units, making a total of 40,000 horse-power.

The Lunkenheimer Company, Cincinnati, Ohio, makers of brass and iron steam specialties, report that owing to the growing demand for their specialties, they have again greatly increased their facilities. They also report through their foreign branches an increasing export demand for their specialties, and state that they will shortly place some new specialties upon the market which will be contained in a very complete catalogue to be issued in the course of a few months.

The Jeffrey Manufacturing Company, of Columbus, Ohio, engineers, founders and machinists, through their connection with the Ohio Malleable Iron Company, of the same place, are now in the field soliciting orders for high-grade malleable castings.

The Toronto & Niagara Power Company have decided to use steel towers on their transmission line from Niagara Falls, Ont., to Toronto, instead of the wooden poles. The towers will be 8 or 10 feet square at the base and 50 feet high at the cross-arms, and will be placed at intervals of 400 feet.

G. M. Gest, subway contractor, of New York and Cincinnati, has been awarded the contract for the construction of a heavy 40-duct conduit system by the Public Service Corporation, of New Jersey. This system will be a main trunk feeder line running through Hoboken and Jersey City. Work is to be begun at once and a large force of men is to be employed to push the work rapidly.

The Riter-Conley Manufacturing Company, of Pittsburg, Pa., has secured the contract for the large steel stack for the power house to be built by the Manila Electric Lighting & Railroad Corporation, Manila, P. I.

On February 2, 1904, Judge Brown, in the Circuit Court of the United States, District of Massachusetts, in the suit of the General Electric Company vs. the Re-New Lamp Company and others, handed down a bill enjoining the use by the defendants of the complainant's trade-mark, "G. E.," on electric lamps.

The Crocker-Wheeler Company announces that the Chicago office has established heaquarters for western Ohio at 1232 Union Trust Building, Cincinnati. H. A. Brown will act as representative at this office.

The American Conduit Manufacturing Company announces that its main office has been moved from New Kensington to Pittsburg, Pa. The better facilities for communication thus obtained will enable the company to render better service to its patrons than before. The company invites all interested in conduit work to call on it at its new quarters. New improvements completed at the New Kensington factory, the company states, have enhanced the superior qualities of American conduit. The new office address is 413 Grant street, Pittsburg.

The Shepherd Engineering Company, of Franklin, Pa., have opened a Western office in the First National Bank Building, Chicago. L. J. Highland is the representative in charge.

The Aultman & Taylor Machinery Company, of Mansfield, Ohio, has secured through the Cahall Sales Department, W. W. Darley, general Western agent, the largest installment of boilers for the Louisiana Purchase Exposition at St. Louis. The installment will consist of eight 508 horse-power and eight 400 horse-power Cahall horizontal water-tube boilers, all equipped with the Mansfield chain grate stokers. The aggregate of these sixteen boilers is 7,264 horse-power. Four of the 508 horse-power boilers are built to carry 225 pounds working pressure, and the other twelve boilers are built to carry a working pressure of 175 pounds. The Aultman & Taylor Machinery Company install foundations, furnish the boilers and do all the brickwork. The total value of the installment is in excess of $165,000. The weight of the entire installment is approximately 3,500 tons, and it will take 125 freight cars to transport same. If the tubes in these boilers were placed end to end they would reach over a distance of twelve miles. The entire sixteen boilers will be equipped with induced draft, furnished by the Buffalo Forge Company. These sixteen boilers constitute about two-thirds of the entire exhibit in the steam, gas and fuel building, and all the boilers will be installed and in operation by April 15.

The Ball Engine Company, of Erie, Pa., is moving into new works on the western city limits and has its old plant for sale, equipped with power, tools, cranes, shafting, hot air heating system, electric light outfit, etc. It began building engines twenty-one years ago, and has sent them all over the world, particularly for electric light and power purposes. The new plant is unexcelled for capacity and facilities of production.

The Gold Car Heating & Lighting Company has moved its offices to the Whitehall Building, 17 Battery Place, New York City, in order to secure more room, necessitated by the growth of its business in electric and other car heating and in car lighting. The Gold Company has moved its Chicago offices and concentrated them with the New York ones at the new address. The company has also made another important move by securing a contract from Mr. T. A. Edison, under which it has the exclusive sale in

the United States for the Edison storage battery for train lighting purposes.

The National Electric Company, successors to the Christensen Engineering Company, manufacturers of air brake and electrical machinery, have just moved their executive offices and engineering department to their new building located at the works. The building is constructed of cement blocks 2 feet long by 1 foot high, and is 200 feet long by 66½ feet wide. Extensions and improvements are also being made in their shops to supply the necessary facilities for handling the company's constantly increasing business.

The recent Baltimore fire has been the means of settling many disputed points for the engineers of this country, and it has, among other points, emphasized most forcibly, in the minds of interested observers, the superiority of underground cables for electric transmission of power as compared with overhead methods. The Standard Underground Cable Company, of Pittsburg, Pa., has installed during the past few years in Baltimore many miles of underground cable, in the municipal subway for the Western Union, Baltimore & Ohio Telegraph companies, the Maryland Telephone Company, the city Fire and Police departments, and the United Railways and Electric Company. The main conduit lines run the entire length of the burned district, and the manhole covers were in many cases covered with piles of hot brick and stone to a depth of 20 feet. In spite of the intense heat, there has been, so far as is known, not a single instance of trouble on the cables in manholes or subway except where exposed ends of cables were destroyed by fire, and the cable system is in perfect condition today. Two three-conductor cables installed for the United Railway & Electric Company over a year ago, and which terminated in the new and unburned portion of the Pratt street power house, extended the entire length of the burned district and were carrying current to the sub-station at 13,000 volts the second day after the fire without any interruption to service. This record, compared with the ruin of overhead construction which was universal, gives food for thought to all users of wire.

The Commissioner of Public Works, Buffalo, N. Y., Col. Francis G. Ward has been authorized by the Aldermanic Committee on Water to prepare plans and procure bids for the installation of a 30,000,000-gallon electric motor driven turbine pump for the water works pumping station.

Doing Business with the Government

THAT doing business with the government sometimes has features both humorous and unpleasant would seem to be the moral of a story printed in the Philadelphia "Record," according to which a Philadelphian who supplies a great many things on orders from Washington recently remarked:

"You can't do business with Uncle Samuel in the spirit of a contract; you simply must obey its letter. If you put in specifications amounting to 'steen dollars and 21 cents, and then bill it goods under the contract and the total amounts to the same 'steen dollars and 19 cents you've got to take it back and make up the other two cents, or you don't do business.

"Let me give you an instance of Uncle Sam's character for exactness. We were awarded a contract for 1,000 feet of copper wire for League Island. We sent the order to the manufacturers, and they turned in the stuff. In a few days we get a letter from the Island authorities that that wire is only 985 feet long.

"We answer that we knew it, that the copper ingot did not yield any more, and that we have charged them only for 985 feet. Would that do? Not on your tin-type.

"They sent us word that if that wire was not brought up to 1,000 feet the lot would be rejected. Then we had to get a permit from the L. A. to send a man down to join on enough to make the demand good, and he went down and did the work.

"In a few days we were notified that the piece he put on made the whole length 1,004 feet. We write back that we didn't care for the four feet and Uncle Sam could have it.

"Next morning up comes an order to cut off that four feet or the whole bunch would be rejected. Then we had to get another permit for our man to go down and lop it off, which he did.

"Was it all plain sailing, then? I should say not. When he threw the offending excess upon the ground the guard said:

" 'Pick that up; that's against the rules.'

"He picked it up, and was about to toss it into the river, when he was stopped in a mandatory way.

" 'Here! You do that and you'll get yourself into trouble!'

"So, thinking he'd find a resting place outside of the Goverment preserves, our employee walked to the gate, where he found a sentinel.

" 'What have you got there?'

" 'A piece of wire.'

" 'You can't carry it without a permit.'

" 'All right. I don't want to,' and cast it down.

" 'You pick that up,' said the sentinel. 'You can't throw things around here.'

" 'But I don't want the d—d thing.'

" 'Go back and get a permit!'

"And he really had to do it to get that four feet of wire outside of Uncle Sam's fence. Now, wouldn't that make you tired?"

A Safety Dress for Electrical Workers

THE idea of a "safety" dress for protection of those whose business requires them to work around high-pressure electrical apparatus appears to be an inviting field for inventors. The idea is not altogether a new one, however, for over ten years ago, when the fatalities due to contact with high-tension overhead wires were numerous, a number of protective devices to be worn on the body were exploited; but so far as known not any of them have been adopted. Somewhat recently Prof. Artmeiff has devised a safety dress of this nature which is said to be quite efficient. The dress, which has been tested in the high-tension laboratory of Siemens & Halske, consists of fine, thickly woven wire gauze which covers the feet, head, and hands of the wearer. Its weight is 3.3 pounds and its resistance is 0.017 ohm from hand to hand, practically inappreciable as compared with the resistance of the body. Wearing this dress, the experimenter freely subjected himself to a number of rather hazardous tests, amongst others, one in which, with safety to himself, he short-circuited with his mailed hands the terminals of a generator that was developing 1,000 volts and 200 amperes. A rule requiring the use of such a dress, however, would probably be found quite as difficult to enforce as the rule which requires the employees of the different electrical companies to wear rubber gloves,—a rule which, notwithstanding that it is obviously in the interest of the employee, is perhaps as often illustrated in the breach as in the observance.

At the regular meeting of the American Society of Civil Engineers, held March 2, the letter ballots on the acceptance of Mr. Carnegie's gift for a union building for the four national engineering societies and the Engineers Club were opened. There were 1,801 votes entitled to be counted, and of these 1,139 were agaisnt and 662 for the project.

From the World's Technical Press

Aluminium Applications

REFERRING to the extending use of aluminium in a review of progress in electrochemistry and electrometallurgy during 1903, John B. C. Kershaw says, in the London "Electrical Review," that a considerable increase in production of the metal is likely to occur in the near future.

The number of works producing aluminium is nine, with two in course of erection. The aggregate power available for the manufacture is still about 40,000 horse-power, equivalent to a production of 11,500 tons per annum, if no other products were made in the aluminium works.

The actual production at the present time, according to the most recent and reliable estimates is, however, only 7,500 tons, and there is a considerable margin between the maximum, and actual, production figures. In the face of this discrepancy, it is somewhat surprising to find that three of the companies engaged in the manufacture (the Neuhausen Aluminium Industrie Gesellschaft, the Pittsburg Reduction Co., and the British Aluminium Co.), are taking steps to increase their productive capacity; and this action on their part would seem to indicate that a rapid increase in the consumption of the light metal is expected in 1904.

As regards utilization, the applications of aluminium as an electrical conductor have, of late, been much discussed. In lithography, aluminium is making rapid progress as a substitute for stone. Already eighteen printing firms in Great Britain have adopted aluminium for color work. Since aluminium offers many advantages when compared with stone, the use of the light metal is certain to extend.

The use of aluminium powder for producing alloys or molten iron at a very high temperature, is being exploited by the firm of Goldschmidt, of Essen, with considerable success, and 100 tons of aluminium in the form of powder is now being consumed per annum for the manufacture of "Thermit," the mixture of aluminium powder and ferric oxide sold for welding purposes. Agencies for the sale of this product have recently been established in Great Britain and America.

The most recent and novel application of aluminium is its use for the manufacture of explosives. An explosive has been patented by Führer, of Vienna, under the name of "Ammonal," and a company has been floated in London with a capital of £100,000 for the exploitation of this new manufacture. Ammonal is stated in the original patent specification to be composed of carbon, ammonium nitrate and aluminium powder in the proportions represented by C, 4 NH_4NO_3, 2 Al, and on firing, a 20-gram charge is said to yield 2,000 cc. of gas. The aluminium powder is added to raise the temperature of the gases, and thus to intensify the explosive effect.

Action of Radium on Living Tissues

IN a lecture recently delivered before the Institution of Engineers and Shipbuilders, in Scotland, Dr. John Macintyre, speaking of the effect of radium on living tissues, said that it possessed the power of stimulation when applied carefully in small quantities and for short periods, but if left in contact with living tissues for a time it produced death.

Ten milligrammes of one of the salts placed on the arm, with a layer of mica intervening, had, as the result of one hour's application, resulted in one case in a burn which lasted for

PROFESSOR AND MADAME CURIE, THE DISCOVERERS OF RADIUM, AND THEIR DAUGHTER
By courtesy of the New York Tribune

four months, and evidently had permanently destroyed the superficial epithelial structures. Many such burns had been recorded. It caused an excitement in the retina when brought near the forehead, and experiments on small animals, such as mice, had shown that it could produce death. A large quantity of radium would be an exceedingly dangerous thing to approach, and even a comparatively small amount, such as an ounce, if it could be obtained, not to speak of half a pound, would be a very dangerous thing to work with.

Experimenters differed in their views as to the results on the growth of plants, and with respect to the effects of the radium rays on bacteria. As to the uses of radium in surgery, Dr. Macintyre preferred to say nothing. Owing to exaggerated statements in the papers, too much had been anticipated of what might yet come, and consequently much suffering had been caused by false expectations having been raised in the minds of those afflicted with serious affections. This he could say, however, that radium bromide did possess a therapeutic value, but what the ultimate result would be was for the future to show.

ELECTRIC MOTOR CARRIAGES HAULING BARGES ON THE CHARLEROI CANAL, BELGIUM

Electric Traction on European Canals

ACCORDING to a report by Léon Gérard, mentioned in the "Bulletin" of the Belgian Electrical Society, three years' experience with electric traction on a portion of the canal between Charleroi and Brussels has shown that the use of an ordinary towpath is impracticable. The towpath in question was admittedly in bad condition, the coefficient of traction being 4.5 kilograms per ton. The number of units taken per barge-kilometer varied with the time of the year, i. e., with the condition of the towpath, between 3.04 in March and 2.24 in October, 1901. The efficiency of the tractors after a year's service is about 0.48. Unloaded and traveling at 4 kilometers per hour, the tractor takes 4.1 kw.; when hauling a barge of 70 tons at the same rate, the power required is 4.85 kw. The wear and tear on the wheels of the tractors, which are of cast steel, is very serious; and Mr. Gérard considers that repairs of all kinds cost three times as much as they do on an ordinary tram line of the same length.

Mr. Gérard also considers the possibility of using tractors running on rails on the towpath. It had been supposed that either heavy tractors would be necessary to secure adhesion or that a rack rail would be necessary. Experiments were undertaken on the canal with a view to finding the pull at starting. With a heavy tractor running on the towpath, and a pull falling from 625 kilograms to 120 kilograms, a speed of about 3.5 kilometers per hour is reached in 50 seconds with a barge of 70 tons; with a tractor weighing 1,650 kilograms, and giving a steady pull of 264 kilograms, the same speed would be reached in about 30 seconds.

Some experiments which were carried out at Oisquercq under rather unfavorable conditions showed that full speed could be reached in about 45 seconds with a light tractor on rails, and this tends to confirm the result of theoretical calculations. Mr. Gérard therefore advises that rails should be laid on the towpath, and that the experiments be continued.

Electric Factory Operation Economies

THE full benefits of electric working, according to London "Engineering," are not always obtained in factory operations, since the saving of losses in line shafting and other ways is so great that it appears almost futile to the management to spend further sums in engine-room refinements. They are inclined to let well enough alone, though it is just in the case of these steady factory loads that a high expenditure at the generating station is particularly profitable. Striking instances of the magnitude of the losses of power ignored in the older conditions of working are constantly recurring. Thus, in one large works, a new manager, on taking charge, found a steam pipe was supplying an engine some hundreds of yards distant, and, to get it out of

the way, this pipe had been laid in a drain through which water was always flowing, and which sometimes ran quite full. An hydraulic engine at the opposite extremity would, perhaps, have been more in keeping with the conditions under which the working fluid was supplied.

In another case a gas engine of 50 horse-power was replaced by a number of motors aggregating 11 horse-power in all. Instances of this kind could be multiplied to almost any extent, and the saving which may be effected in similar cases by the adoption of electrical means of transmission is so great, and makes so good a showing, that the small economies which it is possible to effect by improving the power-station plant seem almost trivial in comparison, and their neglect in certain cases is, therefore, quite intelligible, if not entirely excusable.

Electric Central Stations Operated by Gas Power

IN a paper on "Energy Distribution to Sub-Stations," recently read before the Birmingham, England, section of the Institution of Electrical Engineers, Mr. C. A. Smith remarked that there was no case where the economy claimed for working a large central station of several thousand horse-power by power gas had been tested. Probably no city electrical engineer had seriously considered the subject from a financial point of view, presumably because he was convinced that, for driving large high-tension alternators, gas engines were not reliable.

The idea at once suggested itself that the difficulty would be partially overcome if the size of the unit were reduced, but even then for a city requiring some 40,000 British horse-power for traction, power, and lighting purposes it would be hardly possible to reduce each set below 1,000 British horse-power. Few city electrical engineers would care to use even this size for running alternators in parallel.

To meet this objection it seemed that, if any use was to be made of power gas for producing electricity in bulk, direct currents must be used, and immediately one was confronted with the problem which had prevented the general adoption of direct currents for high-tension work—the troubles of commutation.

Consequently it seemed fairly clear that if producer gas were to be used at all for supplying a city with electrical energy it must be used at the sub-stations, where it would only be necessary to have a comparatively small-unit gas-engine to drive a direct-current generator for supplying the line at the customary voltage up to 550.

German Electric Central Station Statistics

ELECTRIC central stations to the number of 971 were in operation in Germany on April 1, 1903. According to the "Elektrische Zeitung," particulars were available of only 939 of these stations, showing that there were 766 stations with 257,243 kw., using direct current; 45 stations with 30,550 kw., using single or two-phase alternating current; 59 stations with 83,283 kw., using three-phase current, while 67 stations used a mixed system. Of the latter, 55 stations with 102,470 kw., used a combined three-phase and direct-current system, while 12 stations with 8,041 kw., used a combined single-phase and direct-current system.

The 939 stations are situated in 906 cities; 552 stations with 316,235 kw., use steam power, 98 stations with 24,851 kw., use water power, 61 stations with 6,378 kw., have gas engines. In one station with 220 kw., wind power is utilized; 196 stations with 41,861 kw., use both hydraulic and steam power. Of the 939 stations, 339 have a total capacity up to 100 kw., 422 stations a total capacity between 101 and 500 kw., 90 between 501 and 1,000, 39 between 1,001 and 2,000, 30 between 2,001 and 5,000 kw., and 19 more than 5,000 kw.

There are a number of stations which supply current, not to a single town, but to a number of towns. For instance, the Bruehl station supplies 66 towns, at a distance of 9 to 12 miles, with current for light and power. The whole industrial district of upper Silesia is supplied from a single plant, while the water-power plant at the Rhine falls supplies 46 towns. These stations have a very favorable influence on the industrial development of a district. Some larger tramway companies intend to enlarge their tramway stations into stations for supplying light and power over greater districts. In the industrial districts near the Rhine, there are a number of smaller stations which supply current

A SINGLE-RAIL CANAL MOTOR ON THE FINOW CANAL IN GERMANY

for power in houses and smaller shops. For instance, the station of Anrath, near Crefeld, supplies current to motors, each of not more than a quarter or a half horse-power, used for silk manufacture in houses.

Testing Car on the Berlin Electric Tramways

AFTER having for some time used an accumulator tramway-car, running on four axles, for the purpose of taking measurements on their lines, the Berlin Tramway Company have had a special testing-car constructed, which should amply repay the money spent upon it.

According to a description of it, given by E. Björkegren in the "Elektrotechnische Zeitschrift," the car closely resembles the ordinary cars in its outer appearance. It has the same length—11 meters (36 feet)—and general outfit; but it can take up its current either by trolley or contact shoes, and it is well equipped for measuring and experimental purposes. The general arrangement is due to the Union Elektricitäts-Gesellschaft, but the various instruments have been obtained from different sources.

Two of the four axles are fitted with motors, each of 23 horse-power nominally; and any other type of motor used on the system can be fitted. There are three brakes—a hand-brake, a magnetic brake of the Sprague type, and an air brake of the H. H. Böker system. The ordinary instruments and meters have been supplied by the Union and the Allgemeine Elektricitäts-Gesellschaft, the recording instruments by Messrs. Siemens & Halske, and the ampere and voltmeters, provided with double scales for accurate measurements, by the European Weston Company. The speed is indicated, in kilometers per hour, by an instrument by F. Schuchardt, of Berlin, which is actuated by a small dynamo, placed on one of the axles. The distance traveled through is marked in meters by a Gradenwitz instrument, the pointer of which is moved by compressed air. The gradient can at every moment be read off a scale, of which the pointer is connected with a pendulum by toothed gearing.

These instruments are mounted on a switchboard and on a table from which loud-speaking telephones extend to both ends of the car, so that the observer can communicate with the motorman and the conductor. There are two car-controllers, and the car is divided into a testing-room and a sitting room. Among other apparatus may be mentioned a traction dynamometer, to be inserted between the motor-car and trailer-car, supplied by Schäffer & Budenberg, and an insulation tester by Siemens & Halske. Special apparatus for the exact determination of the distance between the rails, the electric resistance of the rail joints, and the radius of curvature are to be added.

Maps and diagrams of the tramway lines are kept on board. The testing-car is rendering valuable assistance to the inspectors and officers who train the motormen. The men can themselves observe the difference between hasty and proper switching, the current consumption during braking, and on inclines, etc., and this demonstration is certainly more useful than oral and printed instructions can be. Certain boards in the floor of the car can be removed, so that the motors and their gearing, the brake-rods, and the air-compressors can be watched while the car is in motion.

The Competition of Steam and Electric Roads

DURING the past two years detailed studies of the competitive conditions existing in eight or ten localities where the development of interurban electric roads is most typical and complete have appeared in the "Railroad Gazette."

According to that publication, the lesson for steam railroads which stands out clear and distinct from a study of these conditions is that there is no profit in competing with electric roads which parallel the main line, except in special, isolated cases.

The railroad manager who attempts to put an interurban road out of business by competing with its rates and frequency of service is in the position of the worthy citizen who was kept awake on a winter night by the howling of his neighbor's dog, and announced his intention of taking the dog to the street corner and holding it there until it froze to death.

Railroads doing an important local or branch line business will probably find that their best recourse lies in control, or partial control, of the competitive territory, following in general the policy of the New York, New Haven & Hartford.

In England, where local passenger traffic supplies a much larger proportion of gross earnings than in this country, extensive experiments are being tried with the electrification of the competitive portions of several railroads, but it is too soon, as yet, to form an opinion as to the way this is going to work out. An electrified road with private right of way and no street franchises gains the advantage of being able to conduct its transportation economically in small units, but still lacks the tremendous terminal privileges of the street car.

Control of the interurban lines in the immediate territory traversed by the steam railroads seems in many ways the best solution of the problem, and lines so controlled should in most cases be able to protect the railroad from indiscriminate competition, bring it new through business, and pay their own way while doing so.

Electric Power in British Shipyards

AMONG the many industries congregated around the districts of the rivers Tyne, Wear, and Tees, says C. S. Vesey Brown, in "Cassier's Magazine," there are none which have made such rapid strides in the last few years in the application of electric power as that of shipbuilding. It is safe to say that in 1894 there was not an electric motor at work in any of the shipyards in the district for the purpose of driving the tools in shipbuilding, and possibly beyond a few motors used for cranes, and dynamos for lighting, there was not any electrical apparatus in regular use. In 1904 the situation is entirely reversed, and, with very few exceptions, there is not a single shipyard which does not derive either the whole or a very considerable portion of its power from electricity.

It is difficult to give any comparative figures as to the relative costs of the old steam power and the new electric installations, owing principally to the fact that as soon as shipbuilders realized the great advantages which electricity gave them to increase their output they added machines as fast as it was possible to put them down to carry on and extend their business. From figures supplied by a shipbuilding firm who adopted electric driving in its early stages, it is possible to give a comparison of the cost of power per "pound of wages paid" in the years 1894 and 1901, that is to say, before and after the use of electricity. The figures are as follows:—In 1894 the cost for coal, gas and labor for driving the engines scattered round the yard was 8.66 pence per "pound of wages paid," and in 1901 the cost for coal, labor and other incidentals for producing the power electrically was 4.88 pence per "pound of wages paid," or, in other words, the wages paid in 1901 were practically double those paid in 1894, and the cost for

power was the same, and this in spite of a very great increase in the number and size of the machine tools employed, which, in the yard in question, practically amounted in 1901 to six times what were in use in 1894.

The cost of producing a Board of Trade unit varies from slighly under a penny to a penny farthing, depending on the load factor, the area of distribution and the size of the plant. These figures of cost include an allowance of 10 per cent. for interest and depreciation on the generating plant and distributing cables.

Metallic Calcium by Electrolysis

THE electrolytic production of metallic calcium from lime, hitherto an unsolved problem, was recently accomplished in the Electro-Metallurgic Institute at Aix-la-Chapelle, by Prof. Borchers and one of his engineering students, Herr Stoekem. The process employed is similar to that of the production of aluminium from bauxite, as described in the "Zeitschrift für Elektrochemie." Aluminium, as is generally known, is separated out of a molten mixture of cryolite and alumina, and the calcium process is even simpler, since only one material is submitted to electrolysis, calcium chloride, to wit, which melts at about 800 degs. C. (1,475 degs. F.).

Certain peculiarities of calcium, not possessed by aluminium, make special care necessary in arranging the electrodes, and even then many failures are encountered. The possession of a method of producing metallic calcium at will, easily and cheaply, is of great importance to chemistry in its application to the arts and manufactures. The metal is not, of course, available for manufacturing vessels, implements or tools, and it does not keep when exposed to the atmosphere, but is converted by it into calcium oxide, quicklime. It is, as remarked, in the chemical industries that calcium will find its greatest usefulness, and especially in organic chemistry, where the need for a cheap metal, with powerful reducing properties, stronger than those of aluminium, magnesium, and zinc, and weaker than metallic sodium and potassium, has for a long time been felt.

The cost of metallic calcium—about $22.50 per pound—has hitherto precluded its use in this capacity (i. e., as a reducer), but, by the new process, this cost is said to be lowered to 45 cents per hundred weight—a fact of which the importance to organic chemistry is impossible to overestimate.

The Telegraphone

PROFESSOR STRECKER, electrical engineer to the German postal and telegraph department, exhibited at a recent meeting of the Electrotechnische Verein some new forms of the Poulsen and Pedersen telegraphóne, which, it will be remembered, was one of the great novelties of the Paris Exhibition of 1900.

It was briefly described recently by "Engineering," of London, as a magnetic phonograph. The currents of the telephone transmitter circulate through the coil of a little electromagnet and magnetize its soft iron core. Under this pole moves—pulled by an electric motor—a ribbon or wire of steel, or a steel disc, just as the paper tape passes under the recording wheel of a Morse printer. The momentary state of the magnetic field, through which it passes, becomes impressed upon the steel tape, and when the tape is afterwards made to pass under a similar apparatus connected to a telephone receiver, the sound is reproduced. That this can be done very distinctly and accurately was demonstrated in London a few years ago, and it is obvious that such instruments might form a valuable adjunct to the telephone. In the new instruments steel wire and steel discs are employed by preference. The wires give a louder sound than the discs, because they can, as a rule, be moved at a faster rate, and the strength of the induction current, by virtue of which the telegraphone operates, depends upon the speed of the motion. The speed is, of course, limited. The wire instrument which Professor Strecker showed was provided with 6 kilometers (nearly 4 miles) of wire, and would suffice for a conversation of forty minutes. Conversations exchanged between Berlin and Frankfort-on-the-Main—a distance of 270 miles as the crow flies—were quite distinctly reproduced by the instrument. A talk with Strassburg, in Alsace, about 125 miles further away, could also be listened to; the reproduction is also described as good, though not quite so clear and loud as with Frankfort. Another type of instrument is intended for magnetically taking down any important conversation through the telephone, the telegraphone circuit being joined up with the ordinary telephone circuit. When used in place of a shorthand clerk for the recording of dictated letters and the like, the disc form of instrument is considered preferable, and the magnetic record forms a spiral line on this disc, just as the incised record does on the plate of a gramophone. A special stop is fitted to instruments of this class, by pressing which the record is arrested, and on restarting does not recommence at the point at which it left off, but repeats a few of the last words already spoken. This arrangement is, it will be seen, a highly convenient one for the typewriter. The sound reproduced is said to be less harsh than it is in the case of the ordinary mechanical phonograph. The "records" can be readily obliterated by passing the wire or disc under the pole of a strong electromagnet, traversed by alternating currents, and a fresh record can then be impressed.

Book News

Elements of Electro-Magnetic Theory

By J. S. Barnett, Ph.D. Published by The MacMillan Company, New York. 480 pages. Price, $3.00.

The title of so important a work as the one before us is not ordinarily chosen lightly, and therefore it is to be assumed that the present title was not selected without due consideration. So many books have already been written on this general subject that it is, doubtless, a somewhat difficult matter to select a title that will not be closely akin to, if it does not actually clash with, those that have preceded it. Perhaps, however, such a title as "First Principles of Electromagnetic Theory," would have conveyed to some minds a more direct idea of the scope of the book than does the title as it stands, unless it was apprehended that such a title would give the impression that the book was a popular treatise on the subject, which it is not.

The work is evidently intended as a text-book for the advanced student or graduate, or, as the author states, for the serious student of physics, and it abounds in formulæ and mathematical analyses. At the same time, when the author employs plain language, as he frequently does, his explanations are clear and intelligible to the ordinary reader,—a statement which cannot always be made relative to writers who habitually and by preference resort to mathematics. Amongst the subjects treated are standard condensers, condenser systems, electric fields with two or more dielectrics, electric absorption, electrolytic and metallic conduction, magnetostatic fields, units

and dimensions, and electric waves. To those for whom the treatise is primarily intended the work will no doubt possess many valuable features, and even the non-mathematical reader will be able to glean much useful information from its pages.

The Lay-Out of Corliss Valve Gears

Reprinted from "The American Machinist," with Revisions and Additions. By Sanford A. Moss, M.S., Ph.D. Published by The D. Van Nostrand Company, New York. 108 pages. Price, 50 cents.

This booklet is one of the well-known Van Nostrand Science series. A complete discussion is given of the theoretical principles underlying the kinematic design or "lay-out" as it is commonly called. This is followed by explicit directions for making a lay-out on the drawing-board. The methods given are rational and may be used by any one. The methods hitherto in use have been rules of thumb, and give good results only in the hands of designers of considerable experience.

Reference is also made to the Corliss valve motion with double wrist-plate and long range cut-off, although the complete kinematic theory of this is not given. For the sake of completeness a preliminary account is given of the usual mechanism of a Corliss valve gear, but beyond this description nothing is given concerning the detailed construction of the various parts, the kinematic features only, rather than the constructive features being considered. It is assumed that the reader is familiar with the theory of the common slide valve.

Wireless Telegraphy; Its Origin, Development, Inventions and Apparatus

By Charles Henry Sewall. Published by The D. Van Nostrand Company, New York. 225 pages. Price, $2.00.

The author begins with a short account of the growth of telegraphy in general, and a brief biography of some of the men of science connected with the development of our knowledge of electricity and magnetism, such as Davy, Faraday, Helmholtz and Maxwell. The rise of wireless telegraphy and Hertz's part in it are then briefly discussed, after which the author jumps into an account of Marconi's transatlantic experiments. Short explanatory notes of the coherer, of attuned circuits and resonance are then given.

It might almost be thought from an examination of the space allotted to the different inventors that the author had determined on giving them space in the inverse ratio of the amount of practical results obtained by each. Thus, eighteen pages are assigned en bloc to Tesla, four to De Forest, three to Lodge, with scattering allusion to Fessenden, Marconi, Slaby and others. There is but little information in the book regarding the practical operation of wireless telegraphy, but patent lawyers and other technically interested in the art may find the somewhat numerous extracts from patents which are given in it, of utility.

The author suggests the term wave-gate for antenna or vertical wire, and he employs the term throughout the book, doubtless to the mystification of those who may not happen to see his definition of the term. Why not the wave-door or the wave-window? A gate presupposes something to be opened or closed, to admit or exclude something. Certainly this is not the function of the vertical wire. At the same time, it may be admitted the term "vertical wire" is not very edifying; but it will probably endure. For no apparent reason the author injects into the book twelve pages of utterly irrelevant discussion of Morse manual telegraphy versus rapid automatic telegraphy and the United States mail service.

The book is well printed on extra heavy paper, and as a specimen of the typographer's art reflects credit on the well known publishers. The illustrations are well executed, and an excellent page picture of Nikola Tesla in characteristic pose is evidently intended to be one of the features of the book.

A B C of the Telephone

By James E. Homans, A. M. Published by Theo. Audel & Co., New York. 346 pages, 268 Illustrations. Price, $1.00.

This book, in its enlarged form and scope, cannot properly be termed an A B C of the subject. Indeed, as the preface intimates, several chapters of the book have been rewritten and enlarged for the purposes of general reference and information. It is difficult to believe that this book was prepared by one versed in electrical matters, theoretical or practical, and it is to be feared that the student who draws from this source will have some things to unlearn. One or two examples of questionable accuracy of statement will suffice. On page 25, one of the principal effects to be observed from direct applications of the electrical current is said to be "the generation of heat by passing the current through a highly resistant wire." Possibly it is overlooked that heat would be developed by a current in an excellent conductor as well. It is further said on page 24 that "the counter electromotive force which, in general, increases in ratio to the true metallic resistance, behaves in many respects like a current, moving in an opposition direction," which, if true, is strange.

The author's lack of a practical knowledge of telephone cables is exemplified in Chap. xxv., where he naively states that "apart from the fact that such a system exists of a number of conducting wires laid or twisted together, there is no resemblance to the structure commonly called a cable"; and we are informed that "telephone cables were devised to meet the conditions incident upon the necessity of running cables underground, particularly in large cities where the law requires it." A cable, it is said, consists of "a length of lead pipe through which is drawn a number, generally 100 pairs, of conducting wires." This will be interesting news to cable manufacturers.

Apart from these items and others of a more or less misleading or mystifying nature the book will be found to contain, in a condensed way, information concerning the history of the telephone, and also many illustrations of apparatus now employed in telephony. There are also some well executed and clearly explained diagrams of telephone circuits. On the other hand, many of the diagrams, and so-called explanations thereof, are not worth the space they occupy for educational purposes.

At a recent meeting of the Milan (Italy) City Council the proposition to establish a municipal electric light and power plant was defeated. This action of the Council insures that the Edison Electric Company will renew its contract with the city.

Orders have been issued by President Mellen to the traffic department of the New York, New Haven & Hartford Railroad Company to equip a vestibuled train with an electric lighting plant, with generators on the car axles. It is stated to be President Mellen's intention to replace gas with electricity all over the line, and this progressive plan is to be put into operation at once.

Telephone connection is said to have been established between the churches and hospitals of Wichita, Kan. The receivers in the churches have been equipped with megaphones and every remark of the pastors is clearly audible in the hospitals.

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THE MANUFACTURES PALACE AT ST. LOUIS

Electricity at the St. Louis Exposition

By W. E. GOLDSBOROUGH, Chief of the Department of Electricity

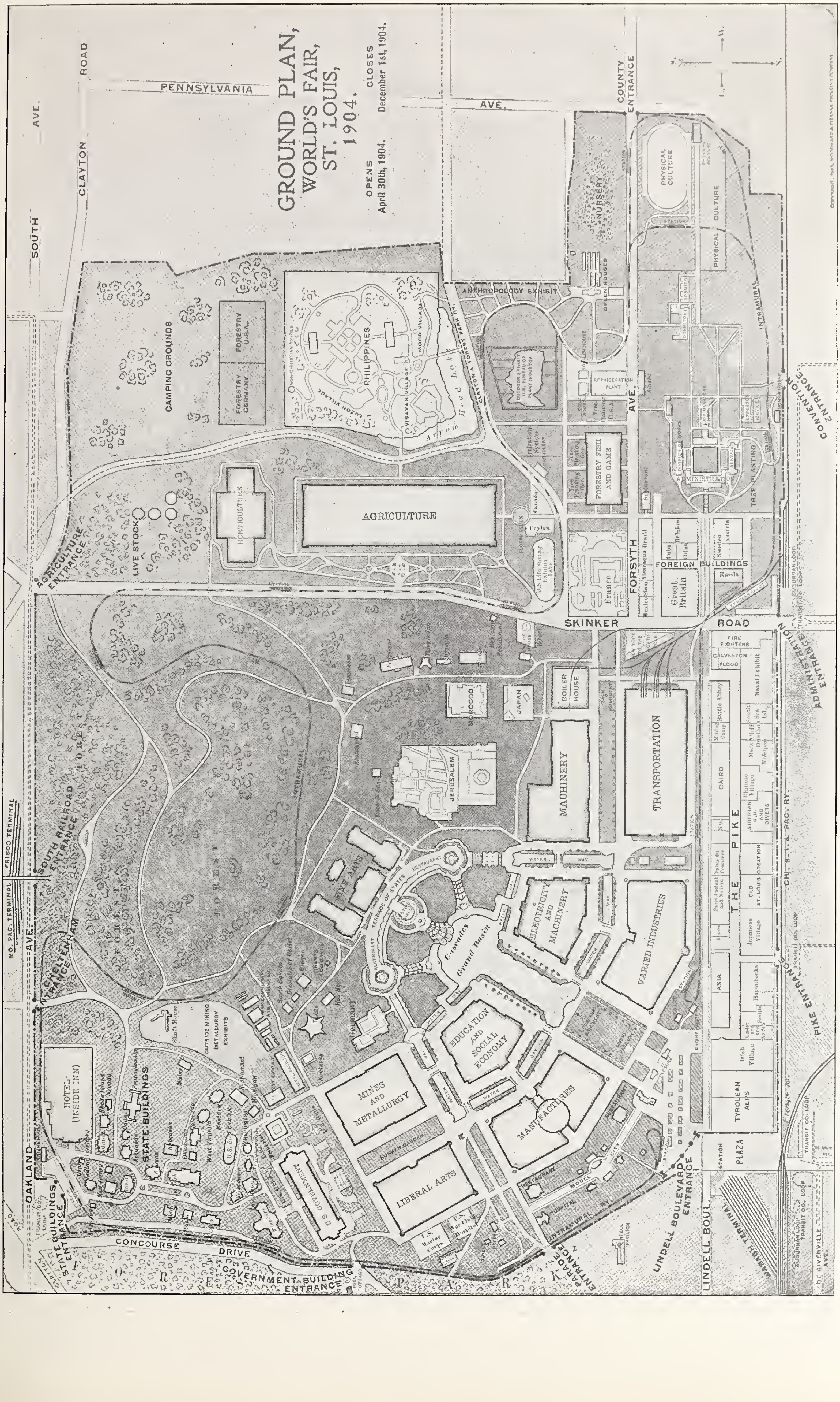
EACH World's Fair is a record of progress in art, science and industry. The time is often too short between recurring expositions to mark a substantial advancement in many lines of effort, but this is not true of electricity. An entire epoch in electrical development is covered by the space of a few years. A scientific discovery opens an entirely new field of research, and each advance in one line has its influence on all others. Apparatus and machinery which a decade ago represented the best engineering effort, now are electrically obsolete. It is this difficult, but fortunate, condition which confronts those in charge of the electrical effects and exhibits at each exposition.

Cumulative experience now enables electrical experts to produce lighting effects which are most spectacular: Such displays are not solely to please the spectators; they educate the public to a better appreciation of artificial lighting. There is no doubt that the Columbian Exposition in 1893 gave a great impetus to decorative lighting, such as may be seen in the theatres, places of amusement, like Luna Park, Coney Island, and along the principal business thoroughfares of any large city.

The main illumination at the St. Louis Exposition will be around the Cascades, Grand Basin and the Palaces of Electricity and Education. It is planned by the experts to be greater in extent and brilliancy than anything ever attempted. On the crest of the hill, in the center of the Exposition grounds, is the Colonnade of States, extending crescent-shaped for more than a quarter of a mile, with the great domed Festival Hall in the center. The Cascade Gardens, 1900 feet wide and 1100 feet deep, slope gradually from the colonnade to the Grand Basin.

The Palaces of Electricity and Education, located on opposite sides of the Grand Basin, require 12,000 electric lamps each, while Festival Hall, with its flanking colonnades and pavilions

THE SOUTHERN FACADE OF THE ELECTRICITY BUILDING


GROUND PLAN,
WORLD'S FAIR,
ST. LOUIS,
1904.
OPENS
April 30th, 1904.
CLOSES
December 1st, 1904.
PENNSYLVANIA
AVE.
CLAYTON
ROAD
SOUTH
AVE.
COUNTY ENTRANCE
PHYSICAL CULTURE
NURSERY
CAMPING GROUNDS
FORESTRY U.S.A.
FORESTRY GERMANY
PHILIPPINES
ANTHROPOLOGY EXHIBIT
REFRIGERATION PLANT
ADMINISTRATION
TREE PLANTING
INTRAMURAL
CONVENTION ENTRANCE
AGRICULTURE
HORTICULTURE
LIVE STOCK
AGRICULTURE ENTRANCE
FORESTRY FISH AND GAME
FORSYTH
FOREIGN BUILDINGS
France
Great Britain
SKINKER
ROAD
ADMINISTRATION ENTRANCE
BOILER HOUSE
JAPAN
MOROCCO
JERUSALEM
MACHINERY
TRANSPORTATION
THE PIKE
CAIRO
ASIA
TYROLEAN ALPS
Irish Village
PIKE ENTRANCE
FOREST
SOUTH RAILROAD ENTRANCE
CHELTENHAM ENTRANCE
FINE ARTS
ELECTRICITY AND MACHINERY
VARIED INDUSTRIES
Grand Basin
Cascades
EDUCATION AND SOCIAL ECONOMY
MINES AND METALLURGY
MANUFACTURES
LIBERAL ARTS
U. S. GOVERNMENT
HOTEL (INSIDE INN)
STATE BUILDINGS
OAKLAND
STATE BUILDINGS ENTRANCE
CONCOURSE DRIVE
GOVERNMENT BUILDING ENTRANCE
PARADE ENTRANCE
LINDELL BOULEVARD ENTRANCE
LINDELL BOUL.
PLAZA
STATION
WABASH TERMINAL
DE BALIVIERE AVE.

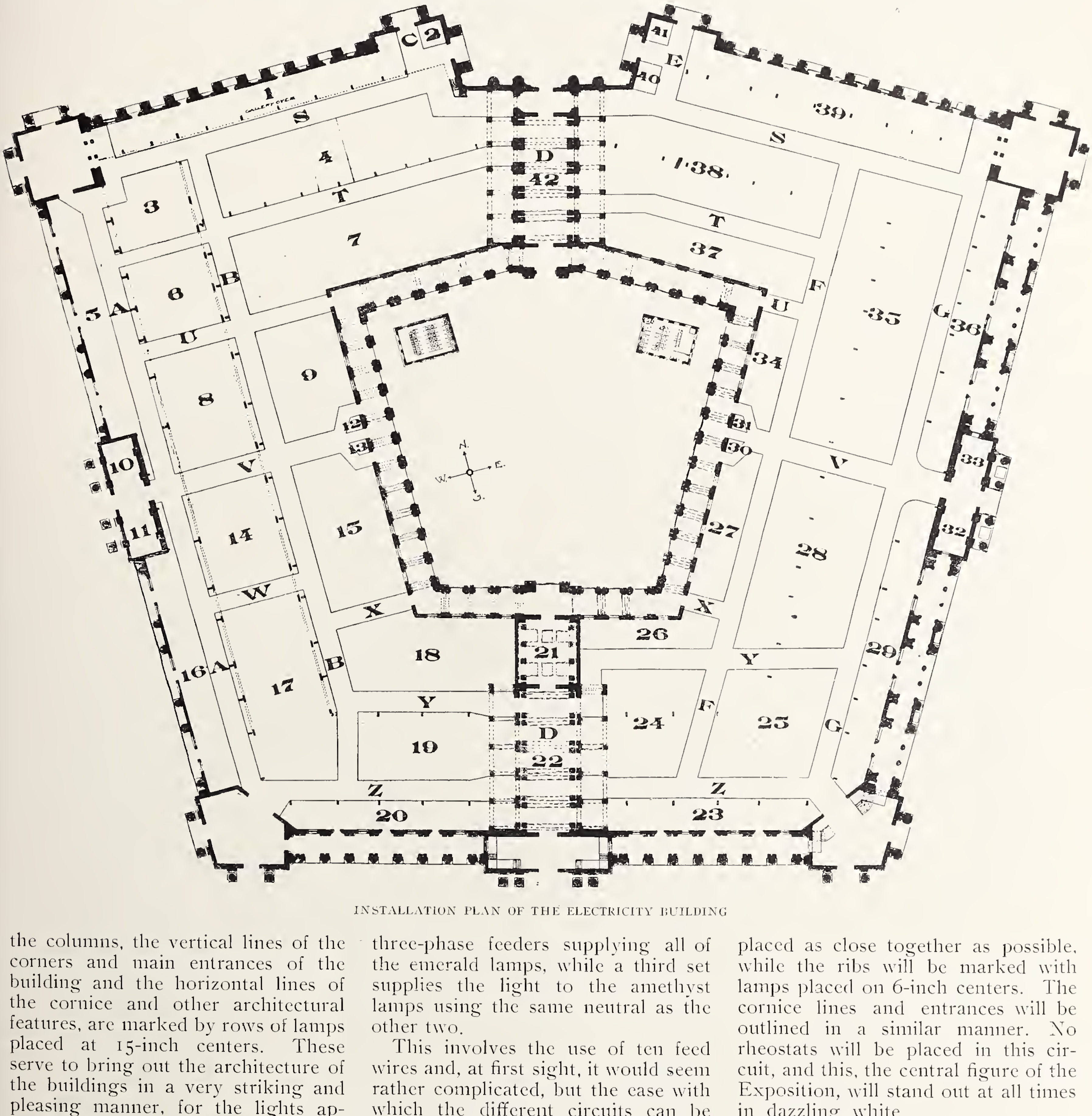
ONE OF THE CORNER TOWERS OF THE ELECTRICITY BUILDING

surmounting the hill at the head of the Grand Basin, has nearly 20,000 lamps. Nearly all of the exhibit buildings incorporate colonnades in their structure. Lamps are placed 15 inches apart on the rear side of the columns, and the light, striking the building walls from 10 to 20 feet behind, causes the columns to stand out sharply against a brilliant white background. In addition to the lights on

In placing the lamp sockets on the columns and pavilions, a triple socket is used in each case, containing a white, amethyst and emerald eight candle-power lamp. The wiring has been done on a triple three-phase system using a common neutral; that is, the feeders from a three-phase system supply the light for all of the plain white lamps. The neutral for this set is also the neutral of a similar set of

cuits, these are under control of one operator whose duty it is to carry the lighting effects through definite and predetermined programmes to be carried out on certain nights.

The exception of this triple-lighting scheme is the Festival Hall, the lights on which will be white. The great dome, rising over 200 feet above the Grand Basin, will be surmounted by several rows of incandescent lamps



INSTALLATION PLAN OF THE ELECTRICITY BUILDING

the columns, the vertical lines of the corners and main entrances of the building and the horizontal lines of the cornice and other architectural features, are marked by rows of lamps placed at 15-inch centers. These serve to bring out the architecture of the buildings in a very striking and pleasing manner, for the lights appear as a solid line rather than a succession of points.

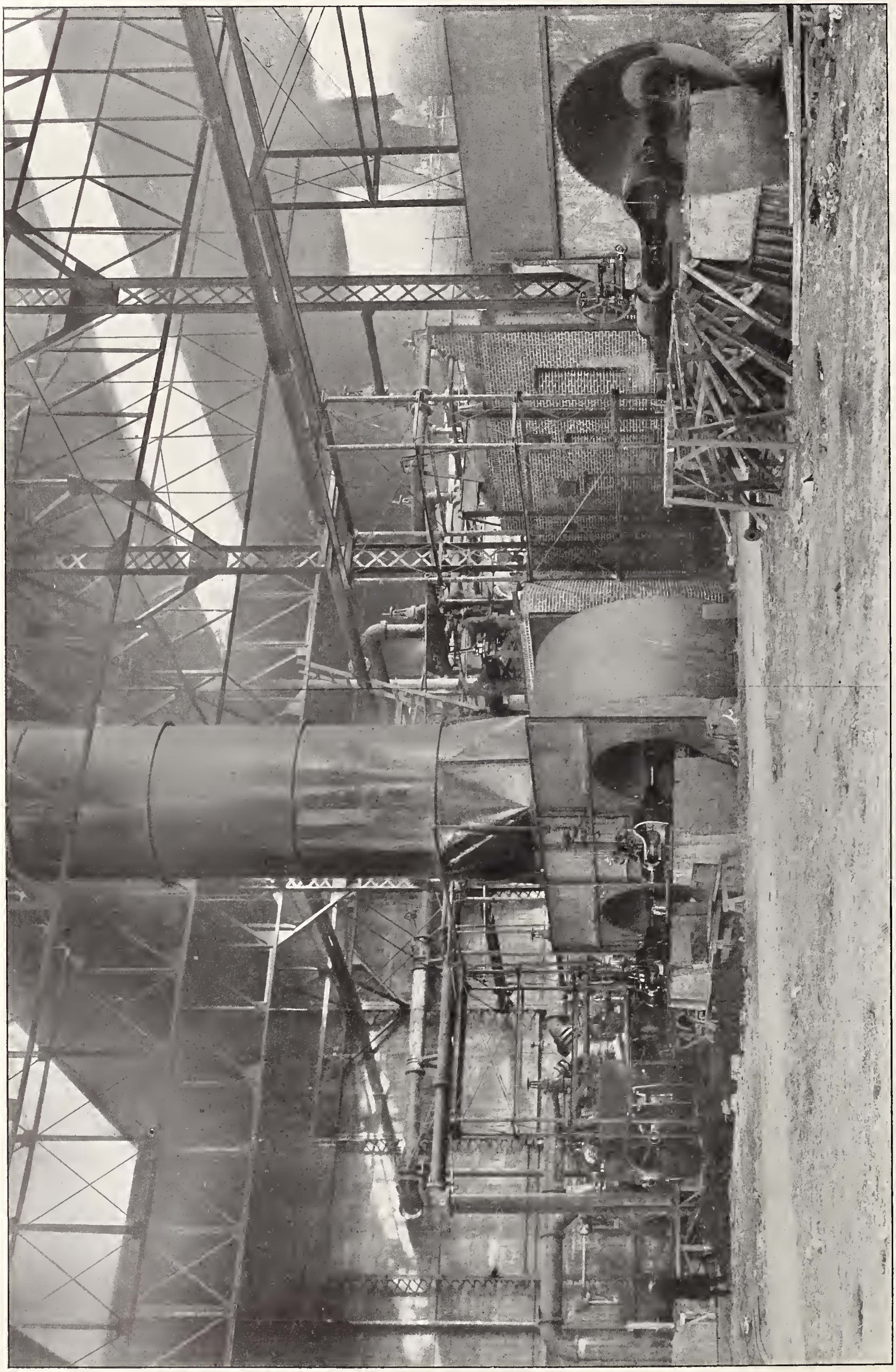
For the illumination of the Colonnade of States, three sets of lights, white, amethyst and emerald are used.

three-phase feeders supplying all of the emerald lamps, while a third set supplies the light to the amethyst lamps using the same neutral as the other two.

This involves the use of ten feed wires and, at first sight, it would seem rather complicated, but the ease with which the different circuits can be controlled and the possibilities of the lighting effects that can be secured, more than compensates for the seeming complication. By means of dimmers, placed in each of the three cir-

placed as close together as possible, while the ribs will be marked with lamps placed on 6-inch centers. The cornice lines and entrances will be outlined in a similar manner. No rheostats will be placed in this circuit, and this, the central figure of the Exposition, will stand out at all times in dazzling white.

The number of combinations that can be produced are almost endless. For instance, the entire area, with the exception of Festival Hall, may be darkened, not a light of any kind ap-



SOME OF THE BABCOCK & WILCOX BOILERS WITH FORCED DRAFT

pearing; then, so gradually that the changes are imperceptible, the emerald circuit may be lighted; then perhaps the emerald light will gradually die down until just before it is entirely extinguished, the amethyst circuit will be built up. The search lights along the roofs of the Electricity and Education buildings will be thrown upon the Cascades, and there will be many other spectacular features besides.

All cornice lines, columns and the architectural decorations of the principal buildings will be studded with incandescent lamps. Outside the central picture the buildings will be suitably lighted, although not so elaborately.

Three cascades, each 290 feet long, descend in a series of fourteen falls. These will be brilliantly illuminated in colors similar to the great columns along the colonnade. The total discharge of water will be about 90,000 gallons per minute, at a head of 159 feet, forming the greatest artificial water fall ever attempted. About 53,000 gallons per minute pass through the main cascade, 23,000 gallons through each of the two sides, and 14,000 through the four fountains in the Grand Basin. Along the main cascade there will be twenty-eight jets playing at the sides. The pumping station is under the east cascade and contains three 2000 H. P. induction motors, direct-connected to 36-inch single-phase Worthington turbine pumps. Water is drawn from the basin through an intake 56 inches wide, 12 inches deep and 750 feet long in order to avoid creating a current in the basin. The water supply is carefully filtered before entering the basin and is simply circulated from the basin to the cascades over and over again.

The power supply for illumination and operating exhibits has been met largely by the building of the largest temporary power station ever erected. It was possible to rent but 7500 K. W. from the Union Light & Power Company of St. Louis. This, however, is only a small percentage of what is needed. A service plant, contracted for with the Westinghouse Electric & Manufacturing Company, consists of four 2000 K. W. generators, direct-connected. The engines are Westinghouse vertical compounds, two of them connected to Westinghouse generators and two to General Electric Company generators.

Besides these two sources of power, there will be also the exhibitors' power plant. The largest item is an Allis-Chalmers vertical-horizontal compound engine of 5000 H. P. capacity, direct-connected to a Bullock alternating-current generator. Several units of the exhibitors' plant are used solely for the current supply to the Intramural Railway. The rated capacity of the installation in Machinery Hall is about 25,000 H. P.

Immediately to the west of Machinery Hall is the Steam, Gas and Fuel Building, covering an area of about 2½ acres. There will be in this sixteen 400 H. P. Babcock & Wilcox boilers, 7200 H. P. of Aultman-Taylor boilers, 3200 H. P. of Heine boilers, 1500 H. P. of Belleville, 800 H. P. of Niclausse and about 1000 H. P. of other makes. Otherwise the boiler house has a complete equipment of coal handling apparatus, mechanical stokers, cooling towers and accessories. Steam tunnels extend from the boiler house only to Machinery Hall, because the distances to other buildings are so great as to make steam piping to them impractical.

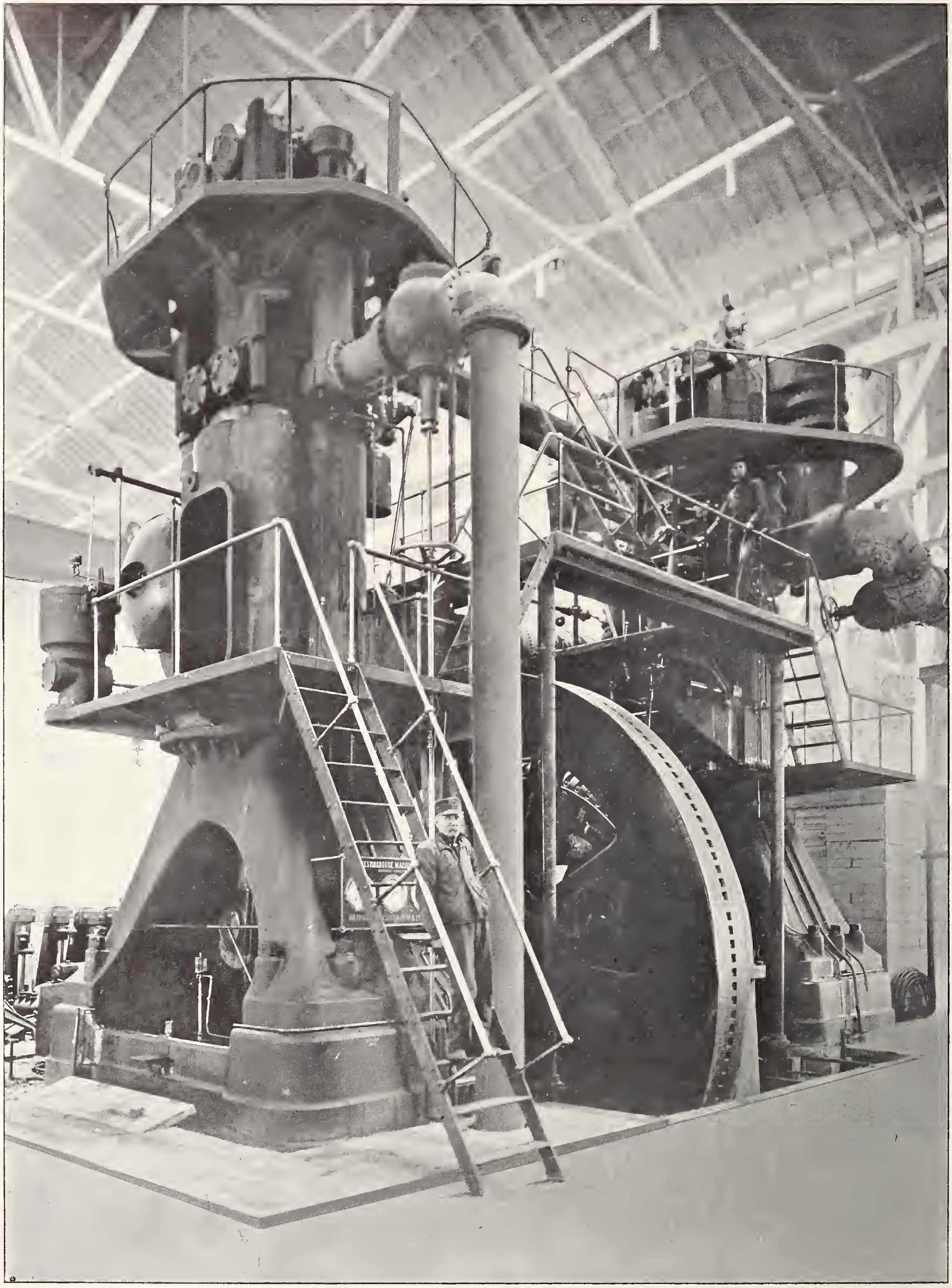
The eastern and southern exposures of the Electricity Building front upon the Grand Basin and are in direct view of the electric fountains, the Colonnade of States, Festival Hall and the Art Building. The west and north sides of the building are flanked by lagoons; consequently it is entirely surrounded by water: No other exposition building is within 300 feet of its approaches. The architects of this building have given the design a bold columnated treatment of the Corinthian order, as may be seen in the view of the south facade on page 186. The columns are carried well down toward the ground, to give height to the facades, which are accentuated by elevated pediments and tower effects over the four main entrances and at the corners.

On two sides of the building are loggias with galleries, from which spectators may view the cascade illumination. On pedestals over the east porticoes are figures of heroic size, typifying the attributes of electricity, "Light," "Power," "Speed," and "Heat." The building has an open central court which will be made beautiful by flower beds and lawns. The court is a pleasing feature of the building, and will provide a quiet retreat and resting place for tired visitors. The corner towers are surrounded by groups of statuary. At the pinnacle is a group, "Light and Darkness," typifying electricity. The two lower groups are entitled "Wonders of the Aurora" and "Wonders of the Lightning." At the main entrances statues of the famous pioneers of electricity will be seen.

The ground plan of the Electricity Building on this page shows the manner in which the aisles and sections have been laid out in the building. A larger percentage of the area under roof has been made available for exhibits than is generally the case in the other exposition buildings. This crowding has been deemed necessary on account of the great and diversified interests centered here. All exhibit space is on the ground floor with ample head room; in fact, over the center sections the roof is 75 feet above the floor. Over Sections 1 and 2 there is a gallery 22 feet wide and 250 feet long, divided and furnished as offices for the department of electricity and as jury and committee rooms.

Beneath the gallery are the main offices of the telegraph companies through which all the news will be sent from the Exposition, and also the booths of the technical press. The central portion of Section 4 is occupied by the sub-station for the building, and contains the transformers

A VIEW OF THE BOILER HOUSE WITH COOLING TOWERS AT THE RIGHT



ONE OF THE WESTINGHOUSE 2000-K. W. UNITS AT ST. LOUIS

and rotary converters. From the power station and from the sub-station mains the following currents are available for lighting and power in the building:

104-volt, 25-cycle alternating current, 1 and 3-phase.

104-volt, 60-cycle alternating current, 1 and 2-phase.

6600-volt, 25-cycle alternating current, 1 and 3-phase.

2200-volt, 60-cycle alternating current, 1 and 2-phase.

2200-volt, 50-cycle alternating current, 1 and 3-phase.

110-volt direct current.

220-volt direct current.

500-volt direct current.

For the distribution of the above service the following plans have been adopted:

104-volt, 25-cycle, 300 K. W. available and distributed over entire building.

104-volt, 60-cycle, 100 K. W. available and distributed over entire building.

110-volt direct current, 220-volt direct current, 500-volt direct current, 300 K. W. available and distributed over building.

6600-volt, 25-cycle, 100 K.W. available at transformer space only.

2200-volt, 60-cycle, 50 K. W. available space only.

2200-volt, 50-cycle, 50 K. W. available at transformer space ony.

In addition to the service mentioned above, there is at the transformer space a limited quantity of 340-volt, 25-cycle, 1 and 3-phase, and 400-volt, 25-cycle, 1 and 3-phase current. These two items are for supplying current to rotary converters and motor-generators installed in the transformer space.

Just east of the sub-station a number of the leading electro-therapeutic manufacturers are erecting booths and preparing for their exhibits. In portions of Sections 3, 4 and 6 will be located the railway exhibits, such as street railway motors, controllers, brakes and electric locomotives. The greater part of the western side of the building is occupied with heavy exhibits for which the traveling crane over Sections 3, 6, 8, 14 and 17 is available. A 30-ton, four-motor Pawling & Harnischfeger crane, with a span of 60 feet, renders this service.

The Western Electric Company occupies a portion of Section 17, in the center of which a motor-generator equipment will be installed, consisting of two 100 K. W. frames, the motor side taking current at 500 volts and the generator side delivering current at 220 volts. This unit will operate in conjunction with a 15 K. W. compensator, permitting the use of 110-volt current. The center space will also contain two switchboards, one for controlling the operation of the apparatus receiving current from the motor-generator.

4-2

In the northeast corner of the space a small machine shop will be installed where there will be exhibited in actual operation some of the modern machine tools driven by Western Electric motors on the three-wire multi-voltage system, and also a line of new motor-driven emery grinding machines. West of the machine shop will be exhibited several direct-connected and belt-driven generators and a number of Cornish cycle engines direct connected to the generators, these sets being especially for marine use.

In the southwest corner of the space will be shown a series of alternating arc light equipment, consisting of a full line of transformers, regulators and switchboards. Opposite this, in the extreme southeast corner, will be exhibited ornamental arc lamp stands from which will be suspended various types of arc lamps; a number of sewing-machine motors will be shown in operation. Fan motors and ceiling fans will be distributed throughout the space, suspended from overhead, and a number of boards containing supplies manufactured for leading companies throughout the country.

In the spaces beneath the crane and adjoining, fine exhibits are now being prepared by the Bullock Electric Manufacturing Company, the Wagner, Fort Wayne, Northern, National and Commercial Electric Companies.

The portion of Section 17 not covered by the traveling crane and adjoining the Western Electric Company on the south, is the exhibit of the American Telephone & Telegraph Company. An operating exchange will be connected with the Bell lines in St. Louis, and the exchange will be housed in a very beautiful booth. This service will permit communication from place to place within the grounds and throughout the city, and will connect with the long distance lines. An exhibitor can thus telephone to a neighboring exhibitor or talk to his home office in New York, Chicago or elsewhere. The telephone company will charge the Exposition Company for this service, and from the Exposition the exhibitor and concessionaire can rent the telephones.

Two of the exhibits in Section 19 will be made by wireless telegraph companies. The American De Forest Wireless Telegraph Company is erecting three wooden towers 75 feet in height, from which antennæ will be strung to the floor and connected to the transmitting and receiving instruments. Messages will be sent to other points in the building and to their large station, which is in the model city, southwest of the Electricity Building. The steel tower of the outdoor station which is now being erected was formerly at the Tower Hotel, Niagara Falls. It is over 300 feet in height, and in addition to serving as a mast, it has three large platforms at and near the top, for observation. This station will be equipped with the most powerful apparatus that has been made in this country, and with favorable conditions, messages will be sent and received at another station in Chicago.

The Thomas E. Clark Wireless Telegraph-Telephone Company is now preparing an exhibit of wireless apparatus, from the first model to the latest type of demonstration and the long-distance instruments, most of them in operation. The exhibit items will consist of wireless telegraph apparatus in all stages of development; wireless railroad safety electric signalling devices, by means of which "rear end" or "head on" collisions can be avoided, where special instruments are placed in the cab of the locomotive to warn the engineer of danger; a wireless telephone in actual operation, a wireless fire alarm system for municipal and private use; marine wireless systems for transmission of messages to and from the shore and separate installations of instruments which will show the location of approaching vessels in fog or darkness, giving audible notice of such approach. The instruments will be shown working under actual commercial conditions, both at the space and at out-door stations. Messages will be transmitted for visitors between the stations and the exhibit proper and vice versa.

When space was being assigned to the foreign governments, Japan made application for space in the Electricity Building to display protographs of electrical engineering work in Japan. It was suggested by the Department that an exhibit of electrical apparatus and machinery of Japanese manufacture would be more appropriate. The Japanese Commissioner doubted his ability to make a creditable showing in this line, but promised to make the effort. His endeavor proved more fruitful than anticipated, for his collection of electrical exhibits not only filled the space assigned, but also an addition. This will, doubtless, be of great interest, for the Japanese engineers who designed and built the apparatus shown were largely educated in America.

The Italian exhibit will be located

in Section 18. This will consist chiefly of fine scientific apparatus and instruments of precision.

Section 35 is to be occupied by Germany, and the exhibit will be particularly strong in the line of electrochemistry. France will cover Sections 34, 37 and 38, and Great Britain is now putting up a facade and installing exhibits in Section 7.

The exhibits of the Kellogg Switchboard & Supply Company, the Automatic Electric Company and the Faller Automatic Telephone Company will cover Section 24. The Automatic Electric Company is now installing two automatic switchboards, one toll board for connecting some manual telephones to the automatic switchboards, a storage battery for operating the switches and also a display of desk automatic telephones. A switch enclosed in a glass case will be constantly operated and fitted with a register to take count of the number of calls made. A handsome booth will enclose this exhibit.

The Faller exhibit will consist of two parts, one showing an entirely automatic telephone exchange, and the second a semi-automatic system. There will be an automatic mechanical operator which, by adding to the present multiple switchboards, will convert these for automatic service.

In the Kellogg space a common battery two-wire multiple switchboard will be shown embodying all the latest features of the Kellogg system. This will be a working exhibit, as the board will be connected by trunks to the exchange of the Kinloch Telephone Company of St. Louis, and will furnish service to one thousand or more subscribers on the Exposition grounds.

A complete line of mechanical signal and lamp signal, private branch and private exchange, switchboards, will also be exhibited, and magneto switchboards for small exchanges. In addition to the above, a bank of magnet wire insulating machines will be in operation.

A historical exhibit is being arranged in section 25 by B. F. Wasson. This will indicate the advances made, step by step, from the most primitive methods of communication to the present state of the art.

The exhibit of the Holophane Glass Company will be one of the most striking in the Electricity Building, for although it occupies a little less than 2500 square feet, it will be lighted by over 1000 incandescent lamps. The booth is in the form of a Grecian temple fronting on three aisles in Section 25. It has a frontage of 77 feet on the main aisle and 31 feet on each side aisle. The main entrance consists of a handsome ornamental doorway, four large pillars being on each side of this doorway. A large center room will be divided into two portions, showing two dining rooms which will be fitted identically, as far as furnishings and fixtures are concerned, but in one case Holophane globes will be used and in the other ordinary globes, so that a person can see at a glance, by looking at the two rooms, the difference in illumination caused by using different globes. On each side of this large room there will be another large room, suitably divided so as to show twelve dark rooms, in which there will be an opportunity to compare the different forms of Holophane globes and Pagoda reflectors with other kinds of globes and reflectors.

On the opposite side of Section 25 there will be a booth of the Weston Electrical Instrument Company. Within will be a display of all kinds of high-grade electrical instruments made by this company, arranged as a standardizing laboratory. The General Electrical Company and Edison exhibits also have conspicuous locations in the eastern part of the building.

The National Bureau of Standards has a series of laboratories covering Section 29, which will be one of the most unique and valuable features of the whole building. A complete equipment of scientific apparatus and instruments in the hands of government experts will enable complete and accurate tests to be made on all forms of electrical machinery. These facilities will be at the disposal of the juries of award, the exhibitors and the department. The result of the work done by this laboratory will furnish a permanent record of the electrical department which will doubtless be of great value.

At this time only an incomplete account can be given of the exhibit features on account of the varying degrees of progress made by the different companies. Practically all the leading electrical companies in the United States are exhibitors, and such care and attention has been given to the plans and installations that the Electricity Building will probably be one of the centers of interest about the Exposition.

The New England Passenger Association and the Trunk Line Association have granted a rate of a fare and a third, from points in their territory to Boston, for the delegates attending the twenty-seventh convention of the National Electric Light Association, to be held in Boston, May 24 to 27.

Elastic Machinery Foundations

MAKING machinery foundations elastic, says "Cassier's Magazine," so as to minimize or even altogether prevent vibration of buildings, is a recently mentioned subject, special reference having been made to the uses of a particular new kind of impregnated foundation felt which is claimed to have given very satisfactory results. It has been spoken of as intended chiefly for insertion beneath rails, girders and machine beds, and as being made in sheets of varying thickness, from ⅜-inch to 1½-inch. The felt is impregnated with mineral fat, so as to be moisture-proof. In Germany it is said to be in extensive use in connection with steam hammers, pumps, steam engines and much other machinery; under bridge girders, railway ties, rail chairs and car bodies; and between columns and joists in buildings, and on shipboard to separate machinery from steel decks and bulkheads. The sheets are made in different sizes up to 60 inches in length x 30 inches in width. Felt mats have for many years been used as anti-vibration expedients, so that there is ample reason to expect satisfaction from the employment of the so-called "foundation felt," here noted; but it may not be amiss to observe that in many instances the apparent desirability of its use is indicative simply of something wrong in the machinery installation. Small earthquakes from the operation of a steam hammer, and trembling buildings from fast-running machinery, often are proofs that the machinery has not been properly put in. Foundations rightly proportioned and rightly laid would materially restrict the market for special foundation preparations and confine their use to the underlaying of rail chairs, bridge girders and such other more appropriate things as have already been mentioned in this paragraph. With these their services would seem to have a fitness entirely lacking where moving machinery is concerned.

A marked increase in the price of iridium, the second in commercial importance of the platinum group of metals, took effect during the last month. This fact is of particular importance to the electrical, chemical and dental industries, which are extensive consumers of the various alloys of iridium and platinum. Recent reports indicate a very marked shortage in the supply of iridium, while the demand for this metal is rapidly increasing.

Underground Conduit Systems for Electric Wires

By C. J. FIELD

A MANHOLE FOR IRON PIPE CONDUITS

UNDERGROUND conduits for electric wires have, commercially, been the development of the past twenty years. They have wrought great changes in the appearance and safety of city streets in that time, having done away with the once common mass of overhead wires. No argument is now needed to convince the public official, the private corporation, or the public at large of the gain to be secured by the public, the manufacturer, the operator and the individual by the installation of conduit systems wherever and whenever the amount of commercial interests and public requirements warrant the increased investment.

Although conduit systems cost from five to ten times as much as those of a corresponding capacity in overhead pole lines, the increased investment is more than counterbalanced by the improved service to the public and reduced renewal expenses. This fact was typically illustrated two years ago by the amount of damage caused to an overhead system in one city of less than 200,000 inhabitants, and the territory surrounding it. The direct loss in repair work by two days' storm was $140,000. As a result, that company has since greatly extended its underground system at a much more rapid rate than it had been doing for several years previous.

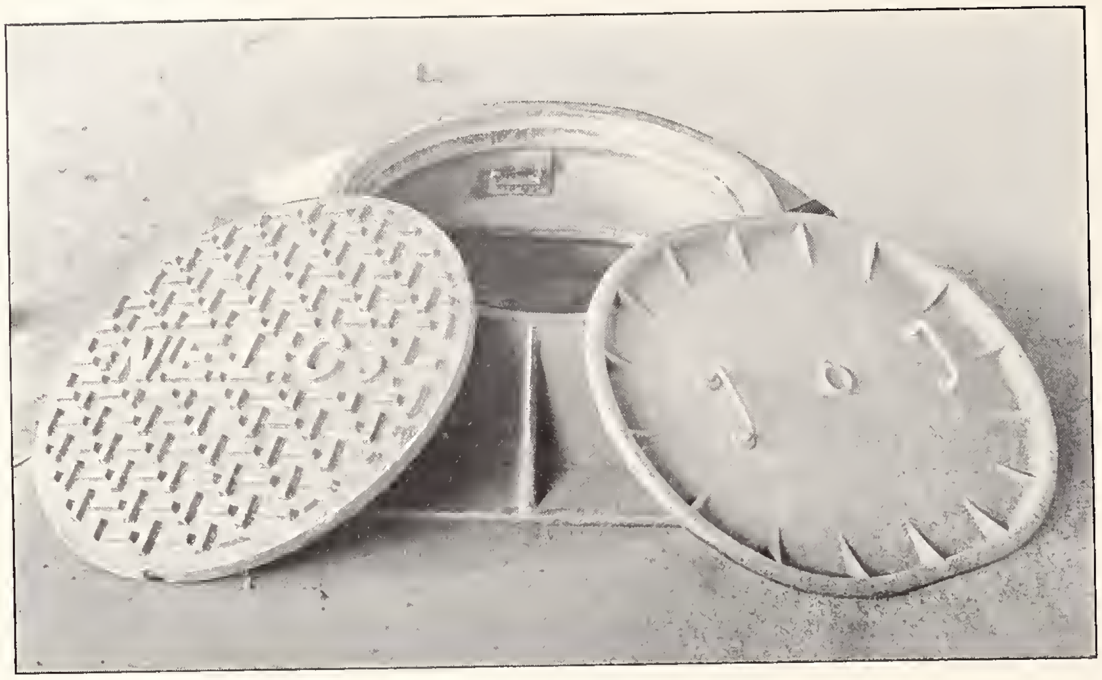
Power, telephone and telegraph companies also are commencing to put their trunk lines underground as fast as engineering and commercial conditions will permit. It is but a step further to the building of underground trunk lines for service between large cities, such as Washington, Baltimore, New York, Boston and others.

A brief review of the different types of conduit systems used abroad and in this country during the past twenty years shows an interesting development. At the outset, the general types of underground conduit in this country were largely creosoted pump log, creosoted boxing, or iron pipe. These conduits were usually laid in the ground without any other than dirt or plank protection. Wood in any form, whether preserved or otherwise, has gradually passed out of use and is employed to-day to only a very limited extent in the smaller class of construction work or for service connections. Iron pipe conduit is now confined mainly to special construction or for local service distribution.

Another method of conduit construction which was extensively used fifteen or more years ago in this country, and which is still used to some extent abroad, is a system of boxing or troughs in which the cables are laid while the trench is still open. A pitch compound is then poured around the conductors and the boxing is covered up. The disadvantages of such a system are manifest. Trying to locate or remedy faults in such an installation means practically rebuilding it. To-day all practical systems in any extensive use in this country must and do provide for a ready method of drawing-in or removal of the cables.

For low-tension electric light service and local distribution with ready facilities for house-to-house connections, the old Edison three-wire tubing system has been the standard for many years. It was introduced in the early 80's at New York, and Sunbury, Pa., and was the first extensive practical and commercial underground distributing system for electric lighting service. For this class of work and service it has for many years continued to be the standard. The system consisted in standard iron piping of standard length, containing three copper conductors or rods as required by the Edison three-wire system, these conductors being separated from one another and from the iron tubing by a spiral wrapping of hemp rope. The two ends of each length of tubing were plugged up after hav-

SETTING A MANHOLE FRAME



A MANHOLE FRAME AND COVERS

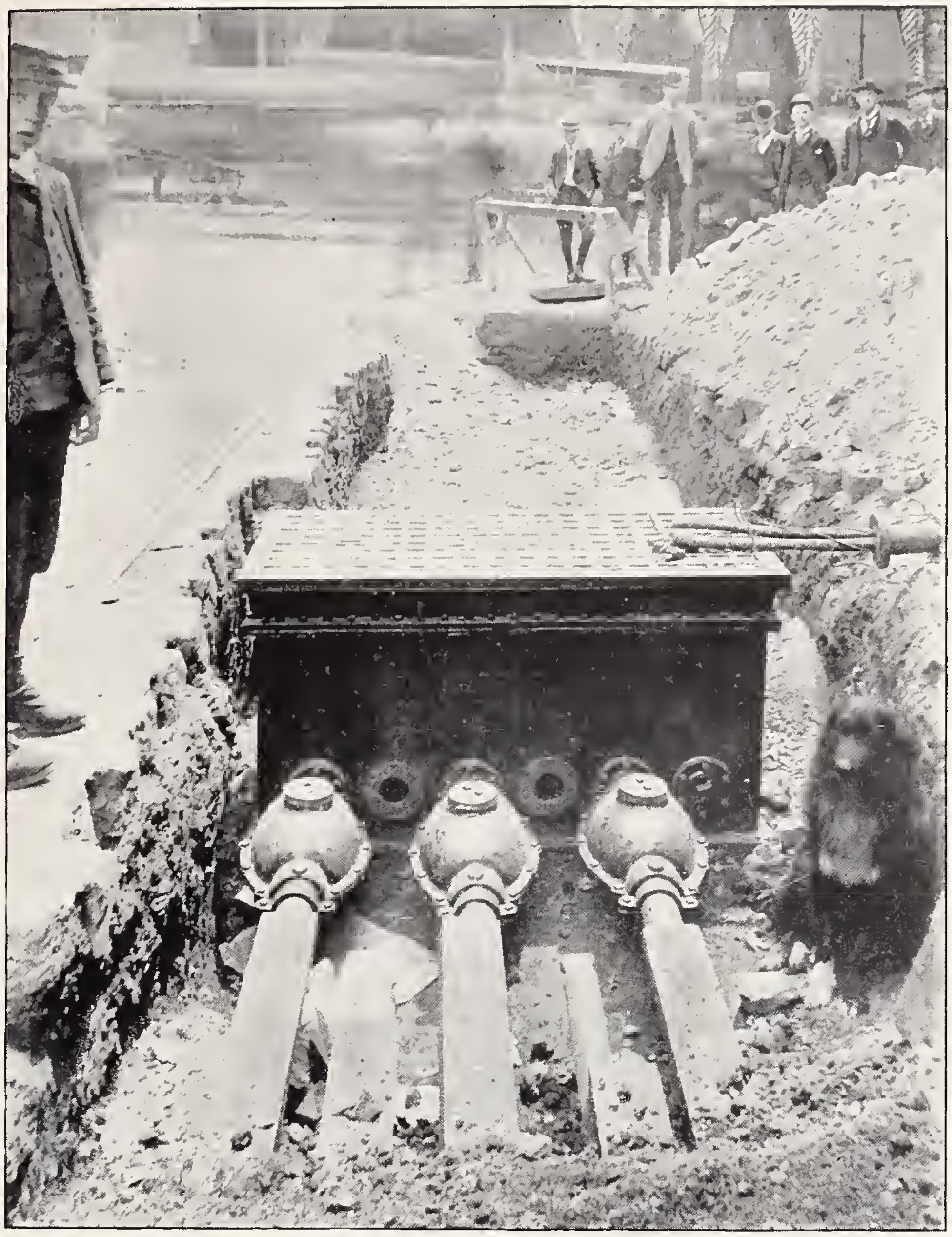
A 32-DUCT CLAY CONDUIT LINE IN BROOKLYN, NEW YORK

ing had a pitch insulating compound forced into the tubing under pressure, the copper rods projecting a couple of inches through the plug at each end. The pipes were connected by means of flexible couplings, about 6 inches long, and a coupling box was placed over them, this box being filled with pitch compound. The joints so formed in the line of pipe at every 20 feet afforded a ready and practical means for making service connections for local distribution, and also a convenient method for locating faults and removing damaged sections. The disadvantages of such a system were in the large number of joints and connections and in its low insulating qualities.

Along with these systems there were in service in the early 90's various kinds of wood, fiber and paper-pulp tubing, and cement-lined iron pipe, all of them constituting the drawing-in system which is now so generally adopted as a standard. These different systems of wood, paper, fiber, cement, etc., have during the past ten years been gradually superseded in all drawing-in systems by vitrified glazed clay conduits, which are now the generally accepted standard for 95 per cent. of the underground conduit construction throughout the world. The earlier systems have continued in use to a limited extent on some special work, or where freight rates were a handicap to the use of clay conduits. The clay conduits have proven the most satisfactory of any conduits ever employed, and have given the best mechanical protection. There is with them entire absence of deterioration, depreciation or maintenance account other than what may be caused by mechanical injury due to other excavations in the streets, and judging from past experience, they appear to be everlasting.

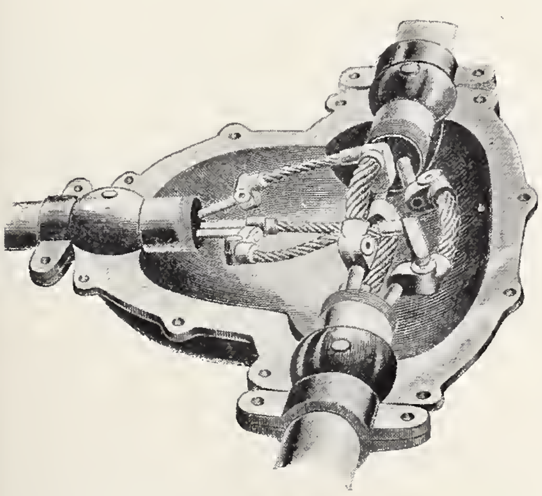
The many advantages of vitrified clay conduit are apparent to the most casual observer, and its general acceptance and specification as the standard on practically all prominent work by both the government and private corporations are further evidence to its excellent qualities. It possesses the advantages of high insulating properties, non-absorbency, resistance against action of short circuits, fire, or gas, or anything else other than mechanical injury. It gives good mechanical protection to the conductors or cables within, and offers a smooth surface with the least resistance for the drawing-in of cables. It has the advantage of very moderate cost, both as to material and installation.

Clay conduits are manufactured in either single or multiple duct types,



EDISON TUBES ENTERING A JUNCTION BOX

covering all the commercial requirements for trunk lines or local distribution. As generally installed in the larger cities, each conduit line is surrounded by a complete concrete envelope three or four inches thick. For smaller cities and towns a concrete



AN EDISON TEE COUPLING BOX, SHOWING SERVICE CONNECTION

bottom and a concrete cover are all that is required. Such a system, while in general depending upon the insulating qualities of the cables or conductors, has the added advantage of being itself an insulator or protection to the cables, and also free from any electrolytic action.

For trunk line or feeder work where no local service distribution is required, manholes are generally located at each street intersection at a distance from one another varying according to local conditions from two to five hundred feet. The duct holes in the conduit system are generally 3¼ to 3½ inches in the clear.

Where local service distribution is required, it is customary to provide this, either from the manholes at the corners or in the middle of the block. Where necessary, a small, separate distributing line of one or two ducts is run on top of the main feeder system and close to the curb, locating thereon from time to time, according to local commercial requirements, small distributing manholes or handholes for taking off connections.

While no underground conduit system is perfect in the attainment of the result sought, the standard systems, as installed to-day and as here described, fully meet the requirements of practical commercial service in the larger cities and towns. They afford a solution of the underground problem and very largely improve the service of all the cities using them for electric distribution in any form, for power, lighting, telephone and telegraph service, or otherwise; and what is more for the benefit of the public and the corporation, they very materially and very largely reduce the cost of maintenance and repairs as compared with the overhead system.

Only a small percentage of the wires in commercial work are underground to-day, yet the requirements of the public and of private corporations are gradually increasing the extent of underground systems and are reducing the number of wires remaining overhead. Where the public requirements demand underground wires, and where transmission companies are not meeting these requirements in a satisfactory manner, the cities themselves have frequently installed municipal underground conduit systems and leased room in them to the different companies. Baltimore supplies one of the most prominent examples of this.

Although undoubtedly there will eventually be many changes in detail and improvements in the general arrangements and form of underground systems, it may be generally accepted

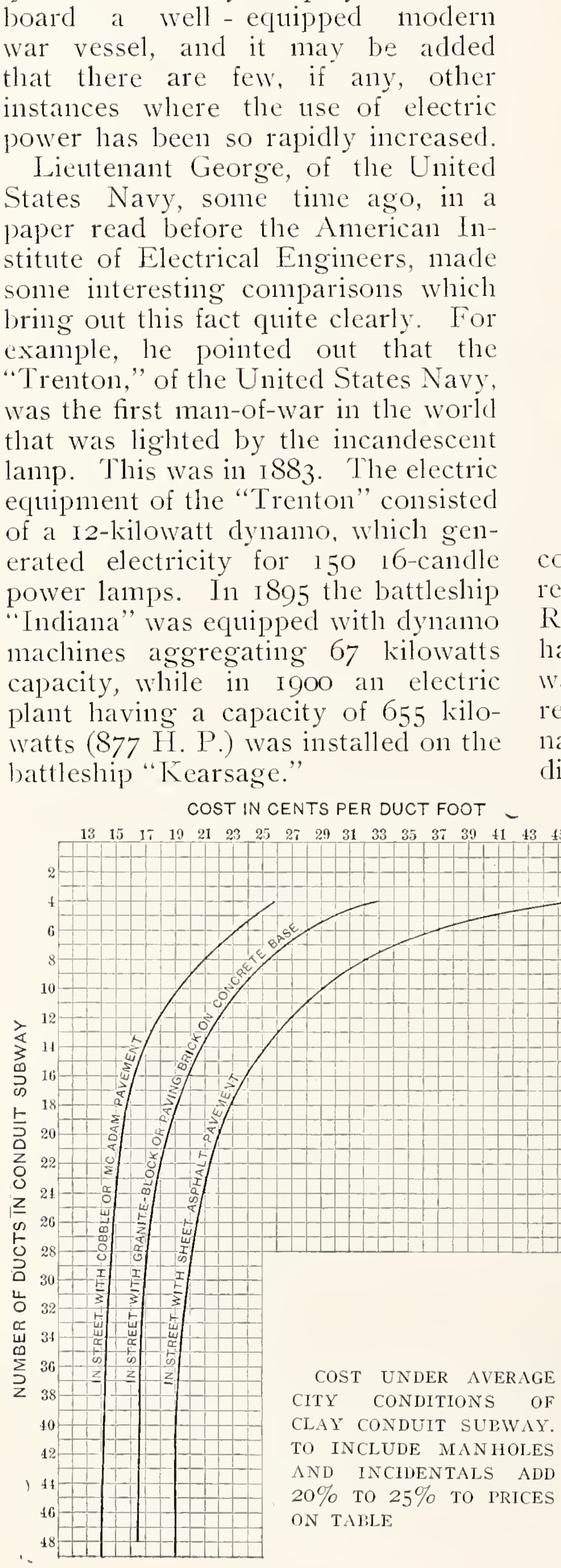
A 4-DUCT CLAY CONDUIT LINE READY FOR ITS CONCRETE ENVELOPE

that the systems as at present installed in the best practice with clay conduits will be the general standard for a good many years to come. There are no stronger advocates of the use and extension of underground systems wherever the commercial requirements are such as to warrant the expense than the progressive corporations and their engineers and managers.

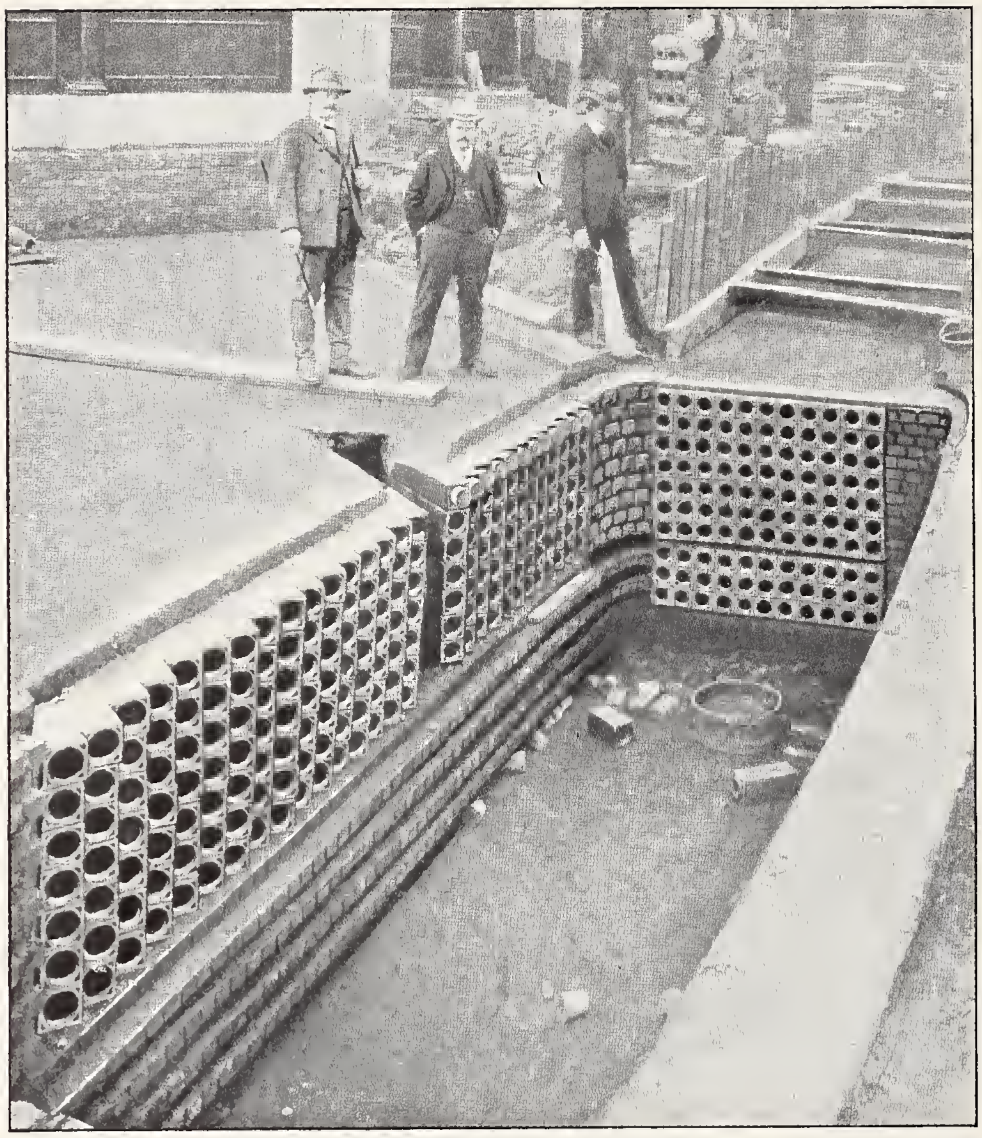
Electric Power on War Ships

THERE are probably few places of corresponding dimensions where electricity and electrical apparatus are so extensively and variously employed as on board a well-equipped modern war vessel, and it may be added that there are few, if any, other instances where the use of electric power has been so rapidly increased.

Lieutenant George, of the United States Navy, some time ago, in a paper read before the American Institute of Electrical Engineers, made some interesting comparisons which bring out this fact quite clearly. For example, he pointed out that the "Trenton," of the United States Navy, was the first man-of-war in the world that was lighted by the incandescent lamp. This was in 1883. The electric equipment of the "Trenton" consisted of a 12-kilowatt dynamo, which generated electricity for 150 16-candle power lamps. In 1895 the battleship "Indiana" was equipped with dynamo machines aggregating 67 kilowatts capacity, while in 1900 an electric plant having a capacity of 655 kilowatts (877 H. P.) was installed on the battleship "Kearsage."



COST UNDER AVERAGE CITY CONDITIONS OF CLAY CONDUIT SUBWAY. TO INCLUDE MANHOLES AND INCIDENTALS ADD 20% TO 25% TO PRICES ON TABLE


OVER THREE HUNDRED CONDUITS ENTER INTO THIS MANHOLE

This equipment of the "Kearsage" compares very favorably with the representative vessels of the German, Russian and French navies, which have generating plants of 325 kilowatts, 588 kilowatts and 295 kilowatts, respectively. The steam engines, dynamo machines, switchboards and indicating instruments of such plants comprise a central station capable of supplying the needs of a fairly large town. From this station electric cables of the most approved make run to every part of the vessel, conveying all the electric power necessary to operate hundreds of incandescent lamps, searchlights and dozens of electric motors, ranging from one-twelfth of a horse power to 50 H. P. These electric motors are used to drive fans, fixed and portable, also the ventilators of the main ventilating system, and for ammunition hoists, for chain hoists of turret guns, for elevating and depressing the guns and for ramming the shells into the breach. The turrets themselves, weighing, with their load, over 600 tons, are turned by 50 H. P. motors, and motors of similar size are employed to operate the boat cranes.

Electric motors are also employed in the more menial capacity of driving air compressors for operating other contrivances. As a means of communication between different parts of the ship, electric call bells, annunciators and telephones are liberally employed.

There are also electric fire alarms, which automatically announce, by the dropping of a small shutter, to the captain's orderly, a temperature in excess of 100 degrees F. in any of the magazines, coal bunkers or storerooms. In addition, there are electric general alarms, warning signals, engine room telegraphs, steering telegraphs and numberless other electric indicators and signaling methods, and last, but not least, a wireless telegraph system. It is almost unnecessary to add, in view of the foregoing, that all modern war vessels are also equipped with an up-to-date electrical library.

It has been decided by the authorities in charge of the Japanese telephone service to employ only girls, both for night and day duty, at the various exchanges. Men were formerly employed for night duty, but this arrangement proved unsatisfactory. This branch of the service gives employment to 3017 persons, of which number 1129 are girls.

The Snoqualmie Falls and White River Power Development

By CHARLES H. BAKER, M. Am. Soc. C. E., Chief Engineer and General Manager

THE newly organized Snoqualmie Falls & White River Power Company, capitalized at $3,000,000, has acquired by purchase the properties of the noted Snoqualmie Falls Power Company, the Seattle Cataract Company and the Tacoma Cataract Company, and it has also taken a thirty-five years' lease of the White River Power Company, which is developing near Seattle, in the State of Washington, a power plant in the White River unequalled in America in size, simplicity and low cost. The White River Power Company was formerly owned by the Westinghouse Electric & Manufacturing Company, of Pittsburgh.

It is now generally conceded that Snoqualmie River and White River afford the only commercial water powers tributary to the Puget Sound communities. While there are numerous streams in that section of the country, and any stream which has positive direction of flow may theoretically be a water power, yet practically it is unsafe to consider any stream as a commercial possibility unless its volume at minimum flow is ample and unless nature has, figuratively speaking, done most of the work in the proposed power development, as is the case at both the Snoqualmie and the White River plants.

It must not be lost sight of that Puget Sound already affords the cheapest fuels in the world for power in the shape of nearby coal and wood and the first serious point to be considered by the hydraulic engineer therefore in order to protect investors, is whether the proposed water power can successfully compete in cost. It is the careful consideration of this condition which bars nearly all the rivers and the streams in the American northwest from having significance as power possibilities. Streams which must be discarded for consideration in Puget Sound, would, if they could be shifted to other fields, like California, Nevada and the Central States, where fuels are high, become important industrial factors and wealth-producing agencies.

In the foothills of the Cascade Mountains, under the shadow of the majestic snow-capped peak of Mount Rainier, the White River Power Company is constructing a power plant which is destined to play a very important part in the development of that country, wonderfully rich in natural resources, lying between Portland, Ore., on the south, Vancouver, B. C., on the north, the Cascade Mountains on the east, and the shores of Puget Sound on the west. Utilizing the water power of White River, a glacial stream having its source in Mount Rainier, the company is constructing near Sumner, Wash., a power plant having a capacity of 50,000 electrical H. P., of which 10,000 H. P. will be ready for distribution within a year.

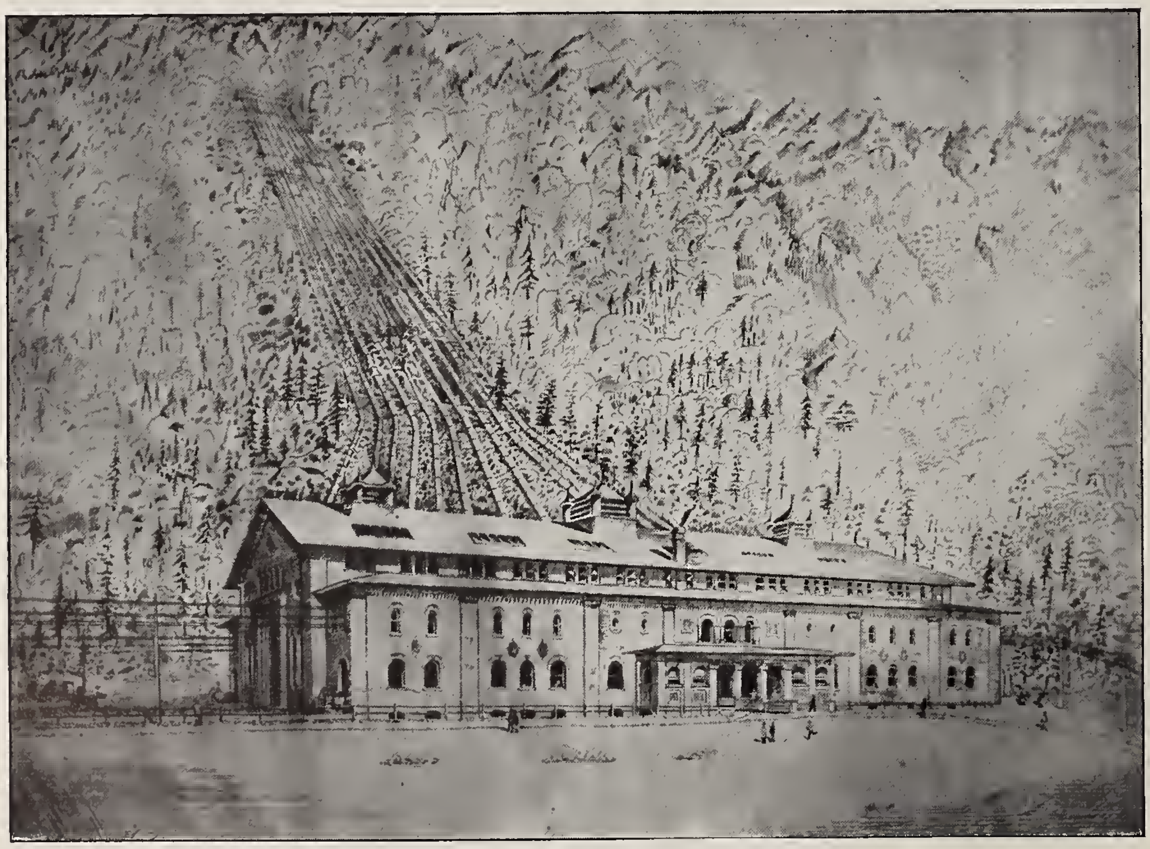
The Snoqualmie Falls Power Company was the pioneer long-distance

THE 11,000-H. P. TRANSMISSION LINES FROM SNOQUALMIE FALLS

THE CREST OF SNOQUALMIE FALLS

transmission company in the Pacific northwest, having a developed capacity of 11,000 H. P., which has been in operation three years.

The White River Power plant will supply current to the same sub-stations as the Snoqualmie plant in addition to such new points of distribution as may be determined upon, the radius of profitable distribution being 250 miles in this territory already abundantly supplied with cheap coal and wood fuels.



THE WHITE RIVER POWER HOUSE OF THE SNOQUALMIE FALLS & WHITE RIVER POWER COMPANY AS IT WILL APPEAR WHEN COMPLETED

The power generated at Snoqualmie Falls has been distributed through the agency of the Seattle Cataract Company and Tacoma Cataract Company. These two companies owned the franchises and the right to sell Snoqualmie power in the two cities respectively. They owned the large and handsome sub-stations at these points and the distribution system throughout the cities, and they marketed the product of the generating plants.

There has been an unprecedented demand for the power generated by the Snoqualmie Falls Power Company. Indeed, this company, both from the view-point of the electrical engineer and the financier, has been an unqualified success. The company's gross earnings have been at the rate of $244,000 per annum, and although its prices have been moderate, its net earnings have been $120,000 per annum, which will be more than doubled after the White River plant is completed. Snoqualmie is turning the wheels of the many factories and

workshops of Seattle and Tacoma, is running the trolley cars of Seattle, which carry 40,000,000 passengers annually. This power enables the Puget Sound Railway Company, commonly known as the "Interurban," to convey more than a million people between Seattle and Tacoma yearly.

The Seattle and Renton Railway Company, which carries 1,140,000 passengers annually, also gets its current from Snoqualmie Falls. This power grinds 9000 bushels of wheat a day at the Continental Mill, and 2200 bushels at the Hammond Mill, both of which plants are located in Seattle. Snoqualmie power treats 650 tons of ore a day at the Tacoma smelter, and runs dentists' burrs in Seattle and Tacoma. The current lights the Seattle post office, the armory of the National Guard at Seattle, the Butler, the Rainier Grand, the Arlington, the Maison Barberis and many of the other principal hotels and restaurants of Seattle. It furnishes power for the Washington Iron Works Company, the largest industry of this kind in the Pacific northwest. It turns the wheels of the Metropolitan Press of Seattle, which prints most of the papers and periodicals published in that part of the country, and it grinds spices and roasts coffee for the Crescent Manufacturing Company. It is the motive force of the Washington Shoe Company, which sends its product all through the Northwest and Alaska.

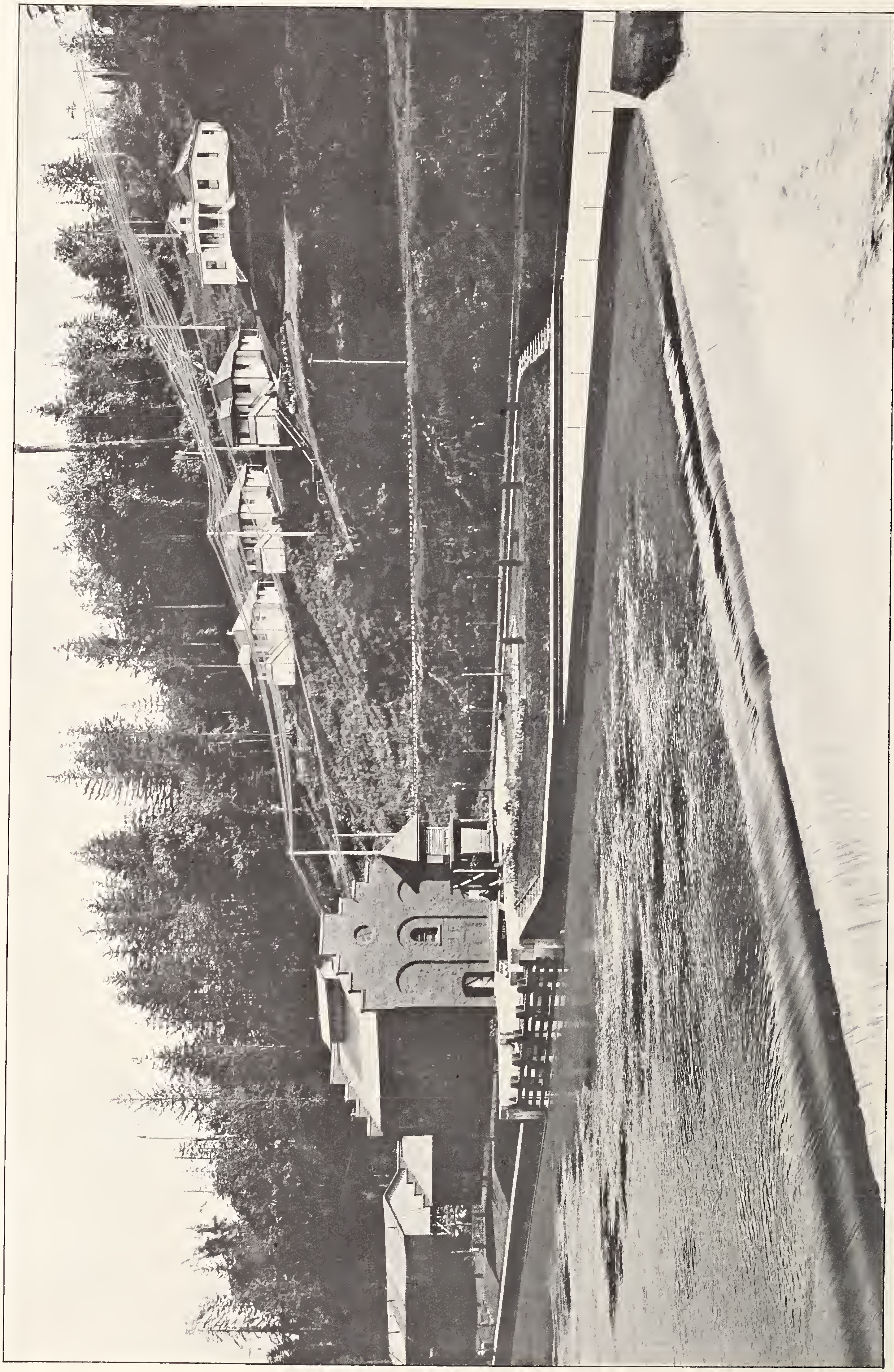
Snoqualmie power runs the machinery of the Electric Laundry, and it lights the First National Bank of Seattle. It grinds flour and feed in the City Mill operated by Lehman Brothers in Seattle, and in the Tacoma Mill and Fransiola Mill in Tacoma. It runs the hay presses of the Galbraith-Bacon Company, and operates its large feed mill. It operates also the smelting works and the machinery of the large jewelry factory owned by Jos. Mayer & Bros., of Seattle, furnishes light to the American Steel & Wire Company, all of the Seattle tracks of the Northern Pacific Railway Company and runs the motors of its machine shops. It furnishes light to many of the stores, saloons and offices in Seattle and Tacoma, and it operates the motors of the countless small industries of both cities

Current is supplied also to Renton, Kent, Polyallup, Sumner, Swansea, Issaquah and Auburn, and the last two mentioned cities also obtain their street lighting from this source. Besides supplying Tacoma with all the power and light for its factories, stores and residences, the Snoqualmie Company has a contract for the entire city lighting.

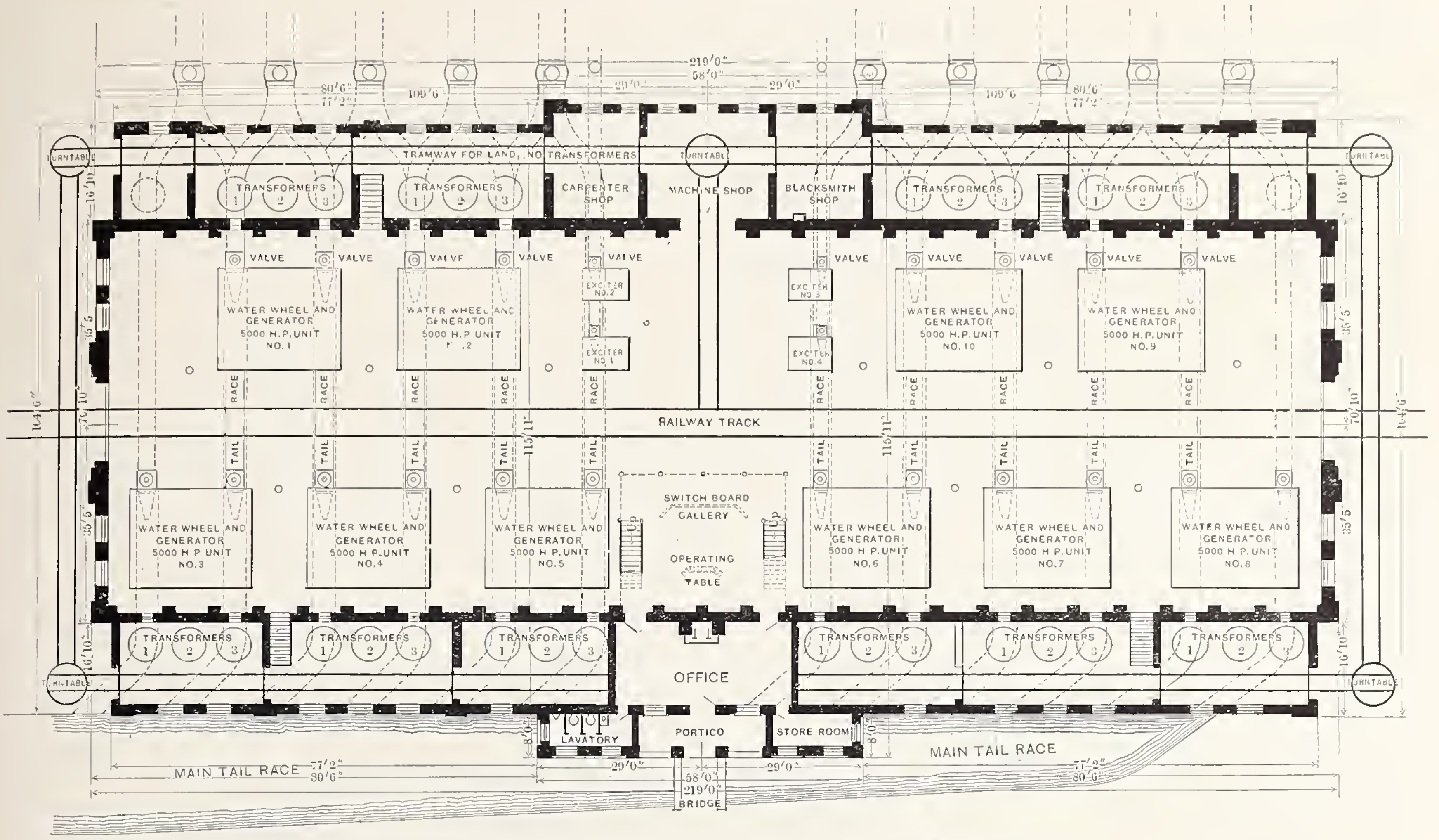
ANOTHER VIEW OF SNOQUALMIE FALLS

Snoqualmie power is further used by the Great Northern Railway Company in the construction of the important tunnel which it is carrying under the heart of Seattle in order to get its trains off the main water front street of the city. Not only is the company obtaining the power for its extensive construction work from the Snoqualmie & White River Company, but that company will, in addition, light the tunnel both during the creative period and after it is in operation. The varied and multiple uses to which the Snoqualmie power is now being put gives, however, only a hint as to the demand that exists for electric current in the rapidly growing section which will be fed by the White River Power Company.

The territory covered by the construction crews of the White River power development extends from Buckley (elevation 660 feet) in the foothills of the Cascades, to Sumner (elevation 65 feet), lying in the level and fertile lower valley at the White River, a distance of 10 miles. The headworks are located about three-quarters of a mile above the Northern Pacific Railway Company's trestle over the White River at Buckley. A concrete dam is being built across the river which will be 9 feet high and 500 feet long. This dam will be



THE SURFACE WORKS AT SNOQUALMIE FALLS. THE WATER IS LED THROUGH VERTICAL PENSTOCKS TO THE WATER-WHEELS IN THE UNDERGROUND STATION PROPER SHOWN ON PAGE 204



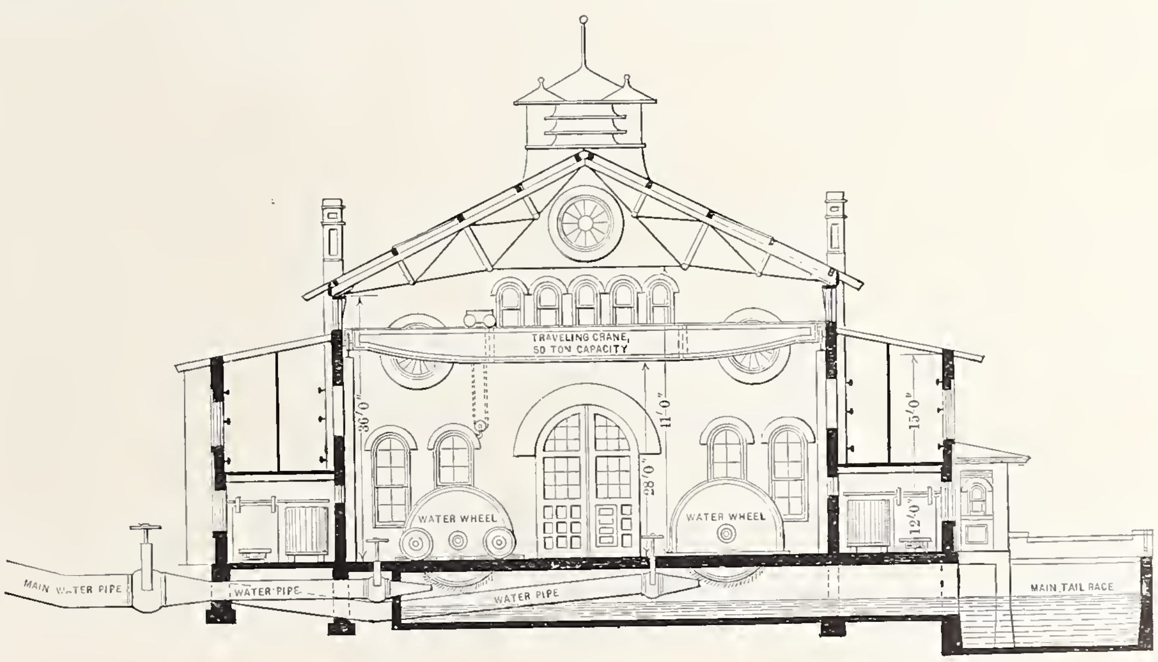
PLAN OF THE POWER STATION OF THE WHITE RIVER POWER COMPANY

provided with a sluice gate and automatic flash boards, which will eliminate injury to the dam from floating logs during the periods of high water. An intake, 120 feet wide, located on the south bank of the river, will lead the water into the first section of an open canal. This canal, 50 feet wide and 5 miles long from the intake to the storage basin at Lake Dorothy, follows an old channel of the White River, and, owing to this provision of nature of a ready-made canal site, it will not be necessary to build flumes at any point of the entire length of the construction work. By the use of four of the largest steam shovels obtainable and 1500 men, this part of the work will be pushed to a speedy conclusion.

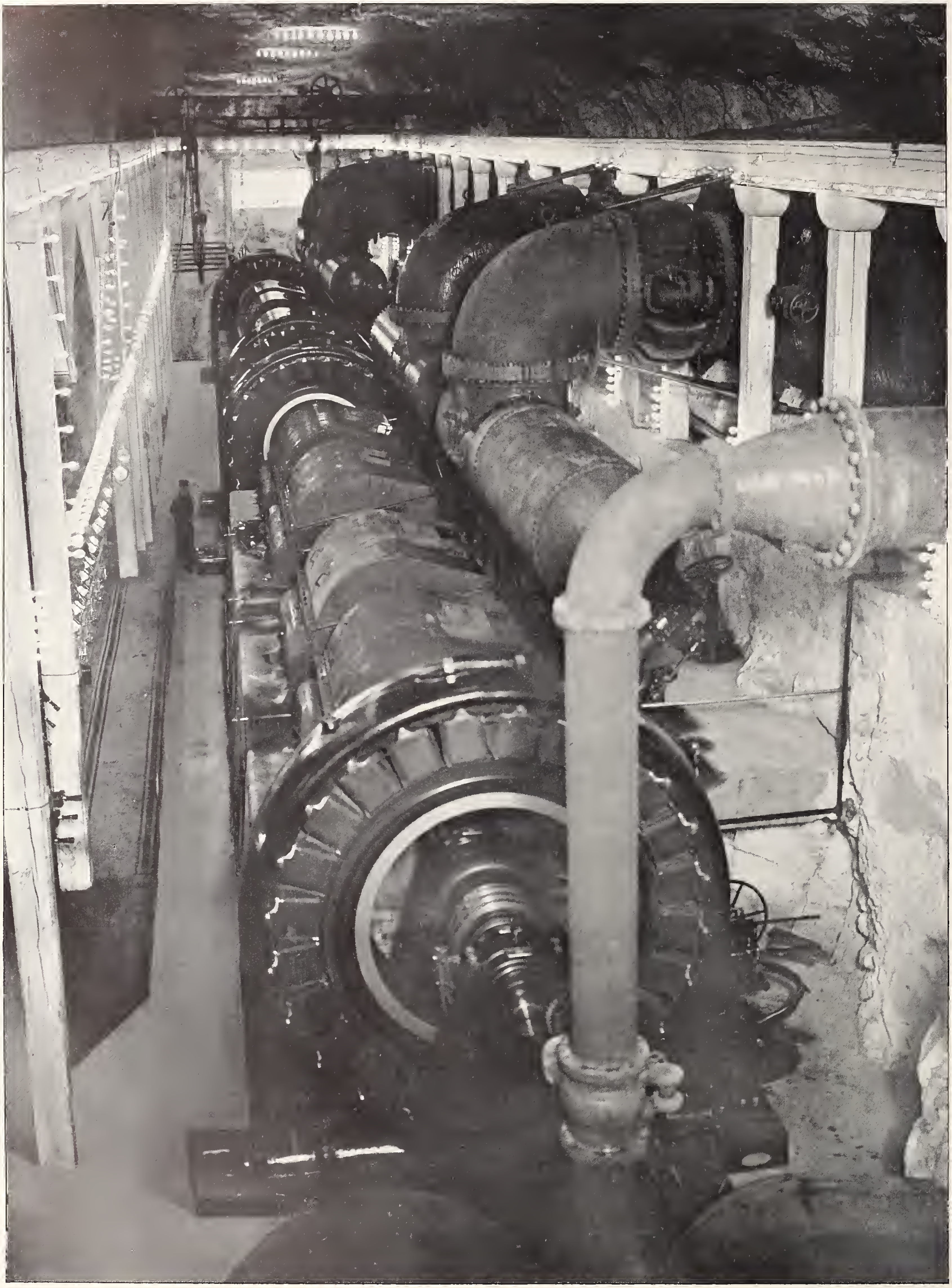
The company is fortunate in being enabled by the natural conditions to develop an engineering plant entirely eliminating all fluming. All wooden flume features are a disastrous attribute of any power plant, particularly where there is not an extensive storage system as a guarantee of continuous service. The Bakersfield plant in California, which depended upon a 2-mile flume, found the service so unreliable, on account of the land slides and rock slides taking out the flume, that they penetrated a mountain with a 2-mile tunnel through solid granite in order to abandon the flume construction. The longer the flume, the greater the liability to disorders. The company is, therefore, fortunate in reducing this feature to a feature as permanent and as free from maintenance charges as the river itself would be.

The White River plant and the Snoqualmie plant have practically the same elevation of intake, namely, 660 feet above sea level. This is a fortunate situation, for if they were any lower it would be at the expense of head, and any increase in elevation would proportionately reduce the area of watershed, and particularly of the rain-fed portion of the water-shed. It must be remembered that the Puget Sound rivers derive their winter flow from rains and springs, and their summer flow from snow and glaciers. The higher the intake elevation therefore, the less the rain area controlled, and consequently the less the power capacity of the river for winter service.

Under the load conditions in Seattle and Tacoma, the power requirements are 35 per cent greater in winter than in summer, and it is fortunate therefore that the flow at the Snoqualmie and White River intake respond to these conditions. An intake located in the upper reaches of these rivers, Puyallup Creek or other streams in that country, at 2000 feet elevation or over, would be able to draw but little water in winter, and if the cold should be especially severe and protracted, as sometimes occurs,



A CROSS-SECTION OF THE WHITE RIVER POWER COMPANY'S STATION



THE UNDERGROUND POWER STATION AT SNOQUALMIE FALLS

according to the testimony of old settlers, such an intake would suffer a complete lack of water.

Another most favorable feature of the White River watershed is that the snow and glacier portion of it faces the north, and being thus sheltered from the hot summer sun, it melts more gradually and later in the year, thus promoting a higher low-water stage in the late summer. The Puyallup and Cowlitz glaciers, lying upon the southern slope of the mountain, disappear much earlier, so that these rivers suffer a more marked and protracted summer low-water proportionately.

The first 1300 feet of the canal are being excavated along a side hill, and will be lined with rubble stones. At the bottom, this part of the canal is 25 feet wide with slopes of $\frac{1}{2}$ to 1, and the water will have a depth of 10 feet. From this point the canal, lined with concrete, crosses the country road, which will be bridged, and tunnels the embankment of the Northern Pacific Railway. Then the canal passes on to a series of alternately narrow and broad benches, which at some remote period formed the bed of the White River itself. These benches are open on the north—the river side—and sloping toward the south they are surrounded on three sides by a higher bench forming the flat part of the main land or plateau.

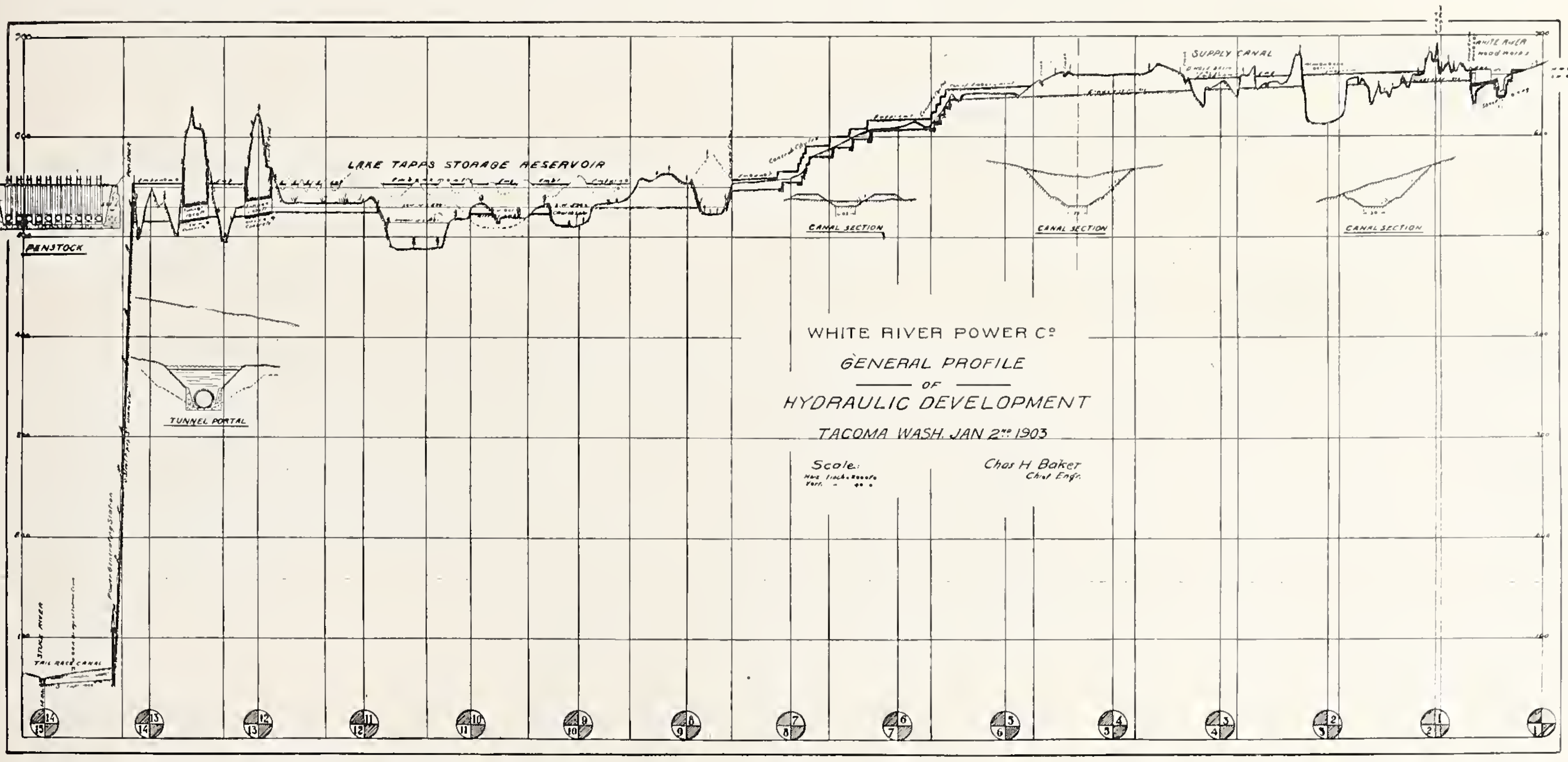
The geological formation of the country through which the canal passes is cement and boulder gravel. On this foundation will be deposited, by the natural action of the water, the white sediment from which the river gets its name. This sediment is a glacial silt, formed by the scraping of the glaciers of Mount Rainier on the rock, and its characteristics are such that after it becomes caked it is practically as impervious to water as rubber. By the use of this substance the seepage of the canal will be reduced to a minimum at the outset, and it is expected that within two or three years it will be entirely eliminated.

The elevation of the intake was so established that it made it possible to lead the canal into four lakes, respectively, Hart Lake, of 8 acres; the McHenry Lake, of 68 acres; the McHugh, of 11 acres, and the Campbell Lake, of 35 acres. In order to supplement the work of nature it will be necessary only to build several low embankments, the material for which will be furnished by the earth taken from short cuts between the respective lakes. Like the canal, these lakes will be rendered water tight by the deposits of glacial silt. In them the white sediment will be made to settle in order that none of it shall be carried into the storage basin at Lake Dorothy.

After leaving the settling basins, the water is carried from the intermediate bench through a cut to the high bench, and from that point traverses the main flat country in a westerly direction for $3\frac{1}{2}$ miles until it reaches the Lake Dorothy storage basin. This section of the canal is 100 feet wide on the surface and 50 feet wide at the bottom, with slopes of 2 to 1, and the depth of the water will be 11 feet. To utilize the settling basins, previously mentioned, the location of the intake was so determined that the canal emerges at an elevation of 100 feet higher than the storage basin. This difference in level will be overcome by guiding the water down over successive shutes to the storage basin. Had the intake been placed so as to avoid the use of these shutes, the canal would have had therefore to be built along the steep side hills of the White River canon, thereby entailing the construction of several miles of flume, a structure that would have been enormously expensive in first cost and maintenance, and in no sense of the word permanent or reliable.

White River, while glacial in its origin, is also largely fed by rain and melting snow. During the winter the flow of water is the largest, for it is rarely cold in that part of the country for any length of time, and the warm Chinook winds cause the snow falling on Mount Rainier and the Cascades to melt rapidly. The floods vary with the precipitation of snow and rain, but the highest flood recorded is 60,000 cubic feet per second. Only in one month of the year is the flow less than 2000 cubic feet, the quantity required for the operations of the company on a basis of 120,000 theoretical H. P. In October the flow drops as low as 600 cubic feet per second, and all of this will be taken with the exception of 30 cubic feet, which the Federal law requires be left in the river to keep the fish alive and for domestic use. During the other months of the year the control gates of the intake will admit only the 2000 cubic feet needed to run the company's water wheels.

Through the magnitude of the Lake Dorothy storage basins, however, the company will always have in reserve a vast volume of water for the use of its generating station, which will be constructed in the White River valley



THE SEATTLE SUB-STATION AND OFFICE BUILDING

near Sumner, below the storage basins. This basin is the most important feature of the whole plan of the White River Power Company, as it is the largest storage basin controlled by any power company in the United States, and is exceeded in capacity only by the Great Lakes which feed Niagara Falls.

Another great advantage of this basin, is that it is situated directly over the station in which the water will be used for generating power. Its location, unlike that of some storage basin remote from the power plant, removes the supply of water from all uncertainties. By the time that the water has reached the storage basin all danger from logs and log jams, from breaks in the jam or in the canal or other causes is entirely avoided.

Until the White River Power Company secured the ownership of the territory surrounding the largest lake, which will be used for a storage basin, this was known as Lake Tapps, its present area being 620 acres. In close proximity are three other lakes, respectively Kirtley Lake, of 80 acres, Church Lake, of 40 acres, and Crawford Lake of 20 acres. Like that of the canal right of way and the settling basins, the natural contour of the country around the storage basin leads one to believe that nature intended these lakes for the purpose that the company is now proposing they be utilized. The present elevation of Lake Tapps is 515 feet above the sea level; that of Church Lake is 530 feet, and that of Kirtley Lake is 526 feet; but work is now progressing on a series of embankments, making it possible to raise the level of Lake Tapps 35 feet, thus securing a water area of 4000 acres which is about seven times larger than the present area. The storage capacity of the Lake Dorothy basin, roughly computed, will be 5,227,200,000 cubic feet, as the average draw-down of water in the basin will be 30 feet, and this means 50,000 H. P. for two months.

The land controlled by the company, extending from Buckley to Sumner, comprises an area of 6500 acres. Of this total area 4000 acres are used for the storage basin, 120 acres are required for the canal and the three settling basins; the headworks cover an area of 10 acres, and the generating station and other buildings in connection with the power plant require 10 acres. A total of 4140 acres will, therefore, be used in the actual operations of the power company. The balance of 2360 acres is controlled by the Lake Dorothy Improvement Company, a corporation organized under the laws of the State of Washington, and will be developed as a pleasure resort by that company.

The power company has a valuable asset in the vast quantity of timber standing on the lands that it has acquired. It has been estimated that the company owns 200,000,000 feet of timber, 50,000,000 feet of which is classed among the best cedar standing in the State; and there are over 100,000,000 feet of fir in prime condition. The canal right of way and basins have been so commonly submerged by the high waters of the White River that forest fires have done very little damage to the timber. Therefore taken as a whole, it is in a better state

of preservation than that in most of the sections of the State.

To utilize this "by-product," the power company will erect a saw-mill in the White River Valley, near the Northern Pacific Railway, which will have a daily capacity of 100,000 feet. It is expected that this saw-mill will be ready for use about the time that the power plant is in actual operation. The output of the sawmill will be disposed of in the open market and will largely enhance the company's revenues.

As a result of the submersion of the ranches contiguous to the storage basin, which will be done as soon as the embankments surrounding the lakes are completed, the whole contour of the country will be very much changed. What are now little hills will then be islands, and the valleys between them will be covered with water. These islands and the shores of the lake, an area comprised of 2360 acres, are controlled by the Lake Dorothy Improvement Company for improvement purposes, and this company has before it an unparalleled opportunity of building up one of the most famous summer resorts of the country.

Nature has surrounded the field of its operations with scenery of marvelous beauty. The country, lying as it does in the foot hills of the mountains, is varied in character, commanding a wide view of the Cascade Range and of the fertile White River Valley as well. The waters of Lake Dorothy will be studded with twenty-two islands of various sizes, but all of them large enough to be susceptible of improvement for summer residences and pleasure resorts. Lake Tapps now has, for a small lake, a widely diversified aspect, owing to the fact that it has many coves and several long arms, which afford abundant opportunity for exploration by the adventurous, whether he be in a launch or in a canoe. This feature of the lake will of course be greatly intensified when the waters of the storage basins are raised 35 feet, bringing about a sevenfold increase in its area.

From no place in the wonderfully beautiful Puget Sound country does one get a view of Mount Rainier, the loftiest peak in the United States, that equals in impressive grandeur the outlook which will be indelibly associated with Lake Dorothy in the minds of those who shall be fortunate enough to go there. Nature has there made a composition that the brush of the world's most famous artist could only imperfectly reveal. With the water of the lake as a most enhancing foreground, Mount Rainier, awe-inspiring, with its great mass of glaciers glistening in the morning sun, or reflecting the glorious colors of the sunset, is artistically framed by the hills surrounding the lake, wooded with Washington's "evergreen."

Owing to the fact that Lake Dorothy is only 10 miles from Tacoma and 24 miles from Seattle, the principal cities of Puget Sound, it will easily be possible to make it a great summer resort. Since the Snoqualmie Falls Power Company parked its property at the falls, it has been one of the magnets of attraction both to the local sight-seers and to the tourists who pass through Seattle. The register of the company contains the names of many of the world's best known men and women who have been held spellbound by the beauty of the falls, and who have marvelled at the work of man in utilizing that great power without in any way destroying its æsthetic quality. During the summer, excursions are taken there at least once every week, and special trains have been run to accommodate delegates to conventions and the like. It is estimated that 50,000 people have visited the falls since the company secured the property which it controls. At Lake Dorothy it will be particularly easy to handle large crowds, as the main line of the Puget Sound Electric Railway now runs within 2 miles of the company's camp, making it necessary to construct only a short spur to reach the lake.

The generating station near Sumner, in the White River Valley, will be housed in a two-story building, of which the main dimensions are 219 x 116 feet. This structure will be built of brick, stone and iron. In this building will be located, on the first floor, the office, a carpenter shop, a machine shop and a blacksmith shop. Railroad tracks run through the center of the station to facilitate the handling of the machinery. These will have a spur connection with the main line of the Northern Pacific Railway Company. A traveling crane of 50 tons capacity will be installed.

Leading from the Lake Dorothy storage basin provision will be made for ten 48-inch pipes, which will carry water to ten water wheels operating ten generators of 5000 H. P. capacity each. All of the electrical equipment of the plant will be of the Westinghouse type. The water flowing through the penstock will have a net fall of 485 feet. Each bank of three

THE SEATTLE SUB-STATION INTERIOR

transformers will be housed in a fireproof compartment. On the second floor of the station will be located the operating galleries and the switchboard.

The generators and transformers are practically connected together and arranged for operating each set of transformers on their own generators, alternate paths being obtainable for operating a set of transformers on any generator for emergency cases. Under ordinary operating conditions the generators will be in parallel only by way of the high-tension connections and transformers. The transformers are connected to the lines in the usual way. Double-break oil switches will be used and will be operated by the electro-pneumatic control.

The generators will be equipped with low-tension watt meters and

THE TACOMA SUB-STATION

high tension ammeters. Integrating watt meters will be placed on each machine to record the total output.

Lightning arresters will be connected to the line through switches controlled by electro-pneumatic cylinders from the switchboard, ammeters being placed in the lightning arrester leads to show when current is flowing through them. In the event of current passing through the arresters, they will be opened by the oil switch and immediately closed, which will usually have the effect of discontinuing any possible arcing and will avoid frequent shut downs which occur by the short-circuiting of lightning arresters.

A very sensitive center zero reading voltmeter, with adjustable resistance in its circuit, will be used for watching and holding the voltage of the plant constant.

The face of the board will carry upon it between the instruments, a diagram of the connections, the voltmeter being used to represent the generator, the current passing from there through the low-tension watt meter, through the transformers in the high-tension ammeters to the respective bus-bars and lines. Breaks are made in the red line diagram, which is thus painted upon the instrument board, and these are backed by red incandescent lamps, the lighting of which will make the appearance of a continuous line through the otherwise open break in the line or bus-bars. The usual duplicate system of exciters will be used with switches for throwing the fields on either or both of the exciters.

For the use of the officers and employees of the company a two-story building, known as the men's barracks, will be erected near the power house, the main dimensions of which will be 68 feet x 45 feet. The first floor of the building will contain a library, a dining room for the men and another for the guests of the company, a kitchen, a photographic dark room and a chemical room. On the second floor there will be rooms for the president, the superintendent and the housekeeper and seven bed chambers, besides the usual conveniences by way of baths and toilets. There will be also a large attic available for sleeping purposes in case of emergency.

The White River generating plant will deliver its power into the same transmission system which is supplied by the Snoqualmie Falls generating plant. This is a most elaborate and substantially constructed system, there being two independent pole lines and two circuits from each generating station to the two terminals. The transmission is on seven-strand aluminium cables supported on imperial porcelain insulators and the spacing of the wires in each circuit is 9 feet in the triangle between centers. The aluminium conductors have given marked satisfaction and the reliability of the service has proved itself unexcelled by any other plant in the country.

The transmission is soon to be extended south in the direction of Portland, and north in the direction of Bellingham.

The Snoqualmie Falls & White River Power Company has something like two and a half millions of dollars invested in its various enterprises and the completion of the plans as they will progress from time to time, with the development of the country, will aggregate an ultimate investment exceeding eight million dollars.

Some European Three-Phase Electric Locomotives

By FRANK C. PERKINS

THREE-PHASE electric railways have been extensively exploited in Europe during the past decade, and some of the most interesting and successful alternating-current railway work has been done in Switzerland, Germany, Austria-Hungary and Italy.

On account of the recent attainment of very high speed with polyphase motors on the newly constructed tracks of the Berlin-Zossen line, it may be of interest to consider some of the three-phase electric locomotives now in use abroad. The fact that the German engineers have been able to travel at the rate of over 125 miles per hour on their experimental line, with good prospects of reaching 140 miles per hour and ultimately much higher speeds, points clearly to a time, at no distant date, when electric power will be applied to long-distance and high-speed trunk lines.

Fig. 1, of the accompanying illustrations, shows one of the first alternating-current locomotives constructed in Austria-Hungary, at Budapesth, by Messrs. Ganz & Co., who have within recent years equipped an Italian 20,000-volt electric road with polyphase locomotives and high-speed motor cars. The Burgdorf-Thun three-phase locomotive, shown in Fig. 2, was constructed by Messrs. Brown, Boveri & Co., of Baden, Switzerland, who also built the Engelberg electric locomotive shown in Fig. 3, in connection with the Swiss Locomotive and Machine Works, of Winterthur.

The Burgdorf-Thun railway is a three-phase, mountain road in Switzerland, of standard gauge and 25 miles' length. The working trolley lines on this railway consist of two copper conductors 0.32 in. in diameter and supplied with current at 750 volts from sub-stations located at intervals of two miles along the line. The track is used as one conductor and is connected with one terminal at the transformer sub-stations, where the current is lowered from 16,000 volts, at which pressure it is conducted over the transmission line from the power house on the Kander.

Each of the two locomotives and six motor cars are provided with two pairs of overhead sliding contacts for conveying the current to the motors. The freight locomotive has a capacity of 300 horse power and is capable of hauling a train of 50 tons at full speed up the steepest grade of 1 in 40. The locomotive weighs 60,000 lbs., and by reducing the speed by gearing to half the normal rate, which is 24¼ miles per hour, a freight train of 70 tons can be hauled up the steepest grade, making a total train load of 200,000 lbs. with the locomotive. The passenger locomotives and motor cars are each equipped with four 60 horse power, polyphase motors, and the trains make about twenty trips per day between Thun and Burgdorf. The motors are of the 8-pole type, operating with a frequency of 40 cycles per second. The total weight of these motor cars, which are 50 feet long and 6½ feet wide, is 64,000 lbs. They have a seating capacity of about seventy persons, although the trailers carry only about one-third as many and weigh about 12 tons each. The four motors are connected in parallel and are operated by a controller at each end of the car. The motor speed is 600 revolutions per minute, which would give a car speed of 24 miles an hour. At the power house at Kander there are four turbines directly coupled to three-phase alternators, each of 1,200 horse power capacity. These generate current of 4,000 volts, which is stepped-up to 16,000 volts and conducted over the transmission line to the sub-stations already mentioned.

The Stansstadt-Engelberg polyphase road is 14 miles long and is equipped with three-phase locomotives as well as motor cars. The grades on this Swiss mountain road are very steep, and for adhesion a rack is provided. The locomotives are of the type shown in Fig. 3. They are equipped with two motors each, operated from 750-volt overhead conductors. Each motor is of 75 horse power, making the total capacity of each locomotive 150 horse power. The current for operating this line is generated by water power with turbines and direct-connected three-phase alternators.

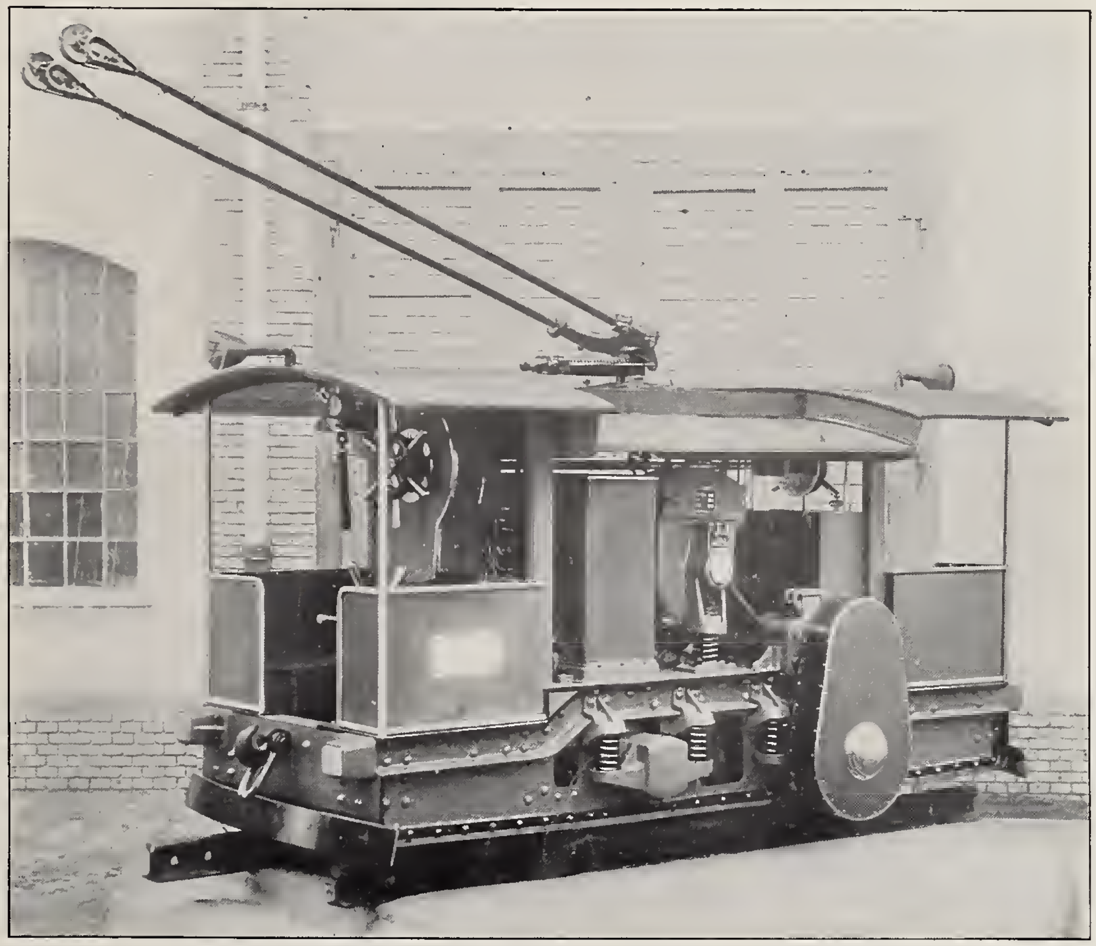


FIG. 1.—A POLYPHASE LOCOMOTIVE BUILT BY MESSRS. GANZ & CO., BUDA-PESTH

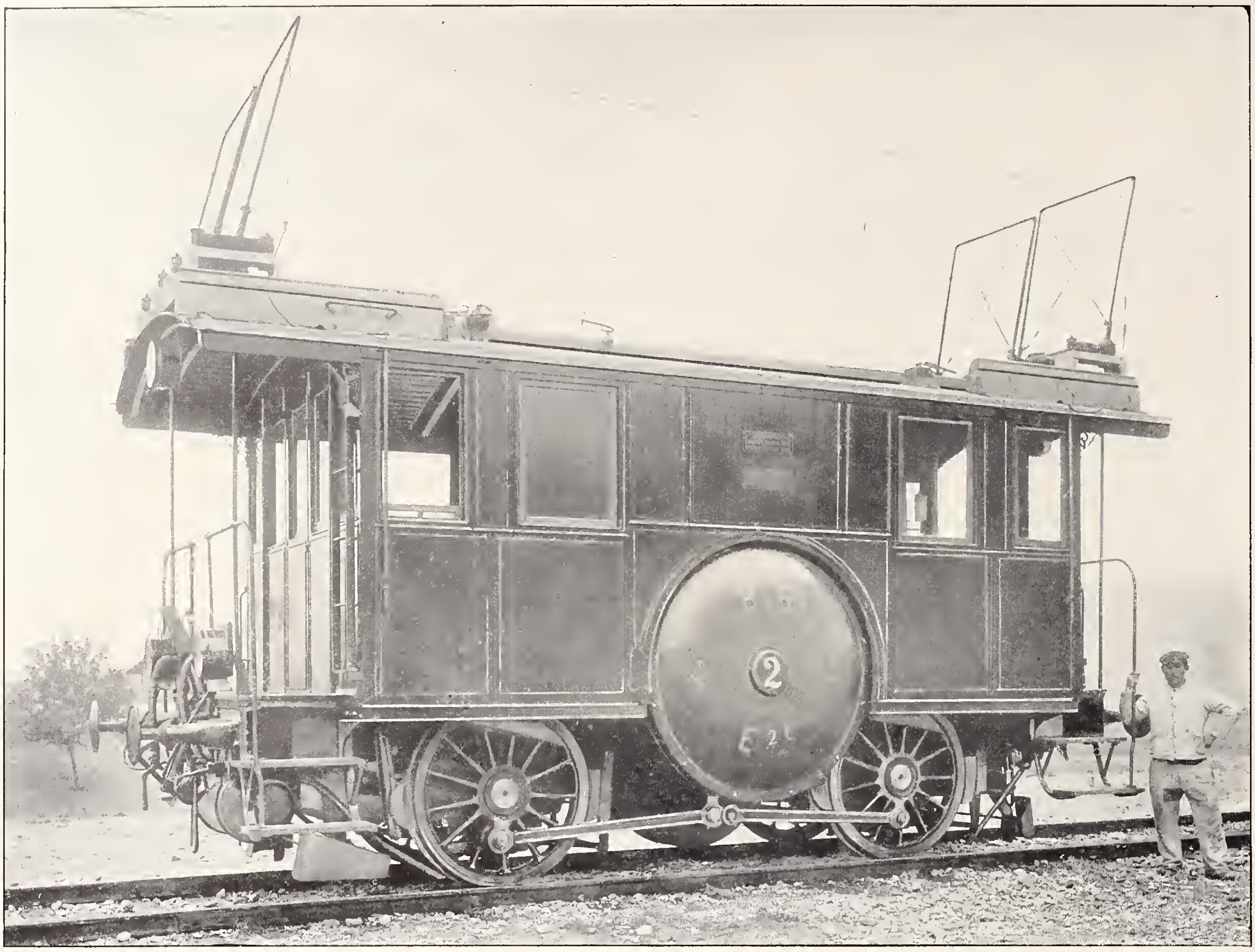


FIG. 2.—ONE OF THE POLYPHASE LOCOMOTIVES ON THE BURGDORF-THUN RAILWAY, BUILT BY MESSRS. BROWN, BOVERI & CO., BADEN, SWITZERLAND

Another Swiss mountain railway using polyphase locomotives is the Jungfraubahn, which is equipped with locomotives of the type shown in Figs. 4 and 5, having a capacity of 400 horse power each, and also a number of smaller locomotives of 300 horse power each. The former were constructed at Oerlikon, near Zürich, Switzerland, by the Maschinenfabrik Oerlikon. Each of the smaller locomotives is provided with two motors of 150 horse power each, having a normal speed of 760 revolutions per minute, and these are of the Brown-Boveri type, constructed at Baden. The Oerlikon three-phase locomotives are equipped with two motors of 200 horse power each, with a normal speed of 500 revolutions per minute. The driving axles are provided with rack pinions of aluminium bronze and with brake wheels and blocks. The sliding contacts noted on the trolley poles take the place of trolley wheels. The maximum gradient is 25 per cent, and a speed of nine to ten miles per hour is easily attained on this steep grade. There are seven miles of tunnels on this line, and about a dozen sub-stations are located at various heights from 6,500 to 13,000 feet above the sea level. Previous to the use of this mountain line the summit could be reached only in two days and two nights, while now it can be accomplished in a few hours.

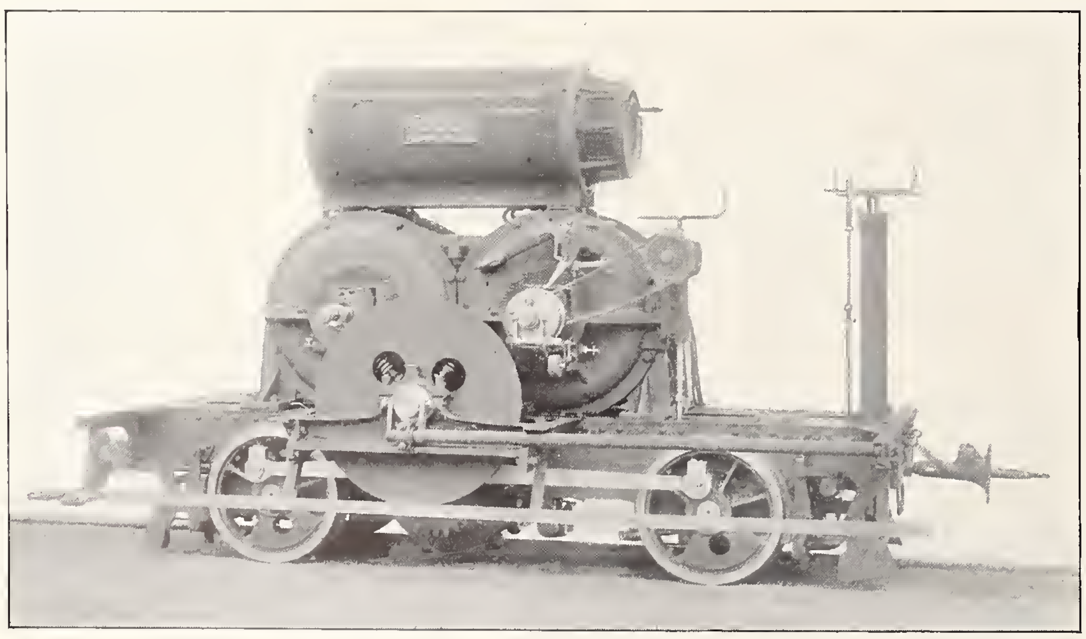


FIG. 3.—THE ENGELBERG ELECTRIC RAILWAY LOCOMOTIVE, BUILT BY THE SWISS LOCOMOTIVE & MACHINE WORKS, WINTERTHUR

At the several sub-stations the current is reduced from 7,000 volts to 550 volts by 200 kilowatt transformers. The high-tension current is conducted on an overhead line 20 miles long from the 2,000 horse power, hydro-electric station at Lauterbrun-

nen. The Oerlikon three-phase alternators at this plant are driven by direct-connected turbines at a speed of 380 revolutions per minute and generate the current at the full 7,000 volts, the frequency being 38 periods per second.

Fig. 6 shows the interior of a polyphase motor car on the Valtellina Railway, in Italy, as installed by Messrs. Ganz & Co., of Budapesth. This three-phase line is 72 miles long, and the electric locomotives are operated at a speed of from 18 to 36 miles per hour. The freight trains of 200 tons are handled by electric locomotives, while the passenger service is performed by trains consisting of motor cars and trailers. The locomotives each have a capacity of 600 horse power, and haul trains with ease up grades of 10 and even 20 per cent, and around curves of 1,000 feet radius. The locomotives are equipped with air brakes and air compressors driven by 100-volt 5-horse power three-phase motors. The current is taken from the 3,000-volt trolley wires by rollers having ends of truncated cone shape, the cylindrical part being about 18 inches long. Current is supplied from about a dozen sub-stations, at which the transmission line current is stepped-down from 20,000 volts to 3,000 volts, as mentioned above. The high-potential transmission line is 10 miles long, extending from Colico to the power station at Morbegno, and continues along the railway connecting with the various sub-stations.

The rollers which take the current from the trolley wires are made of aluminium and are 3 inches in diameter.

At the power station at Morbegno there are four turbines, each of 3,000 horse power, and to each of these is directly connected a polyphase alternator having a normal output of 1,050 kilowatts and a maximum capacity of 1,500 kilowatts. These generators were constructed by the Elektricitäts Actien-Gesellschaft, formerly Schuckert & Co., of Nürnberg, Germany, and generate current of 20,000 volts, making it unnecessary to employ step-up transformers for raising the pressure for the long-distance transmission line. These 20,000-volt alternators are equipped with safety devices or governors which introduce high resistance into the field circuit if the turbine governors should fail to work, and the speed is increased to 170 revolutions, the normal speed being 150 revolutions per minute. The machines are, however, capable of standing an increase of voltage of 50 per cent, which would give 30,000 volts in the armature windings.

The Siemens & Halske polyphase locomotive and motor cars in operation on the Marienfeld-Zossen line in Germany have been most successful in working with pressures of from 10,000 to 14,000 volts directly in the overhead trolley lines. The noteworthy accomplishment of making a speed of 125 miles per hour on the Berlin-Zossen line was also a successful demonstration that high potentials may be used on the working conductors of long-distance electric railways of the three-phase system.

The latest achievement of Herr Walter Reichel, chief engineer of the Siemens & Halske Actien-Gesellschaft, of Berlin, on this high-speed test was due largely to the fine roadbed which was constructed for these experiments. Several motor cars and locomotives have been built by this firm and by the Allgemeine Elektricitäts Gesellschaft for demonstrating the feasibility of high-speed polyphase electric traction.

The first motor car constructed by

FIG. 4.—THE JUNGFRAU RAILWAY LOCOMOTIVE, BUILT BY THE OERLIKON MACHINE WORKS, ZÜRICH, SWITZERLAND

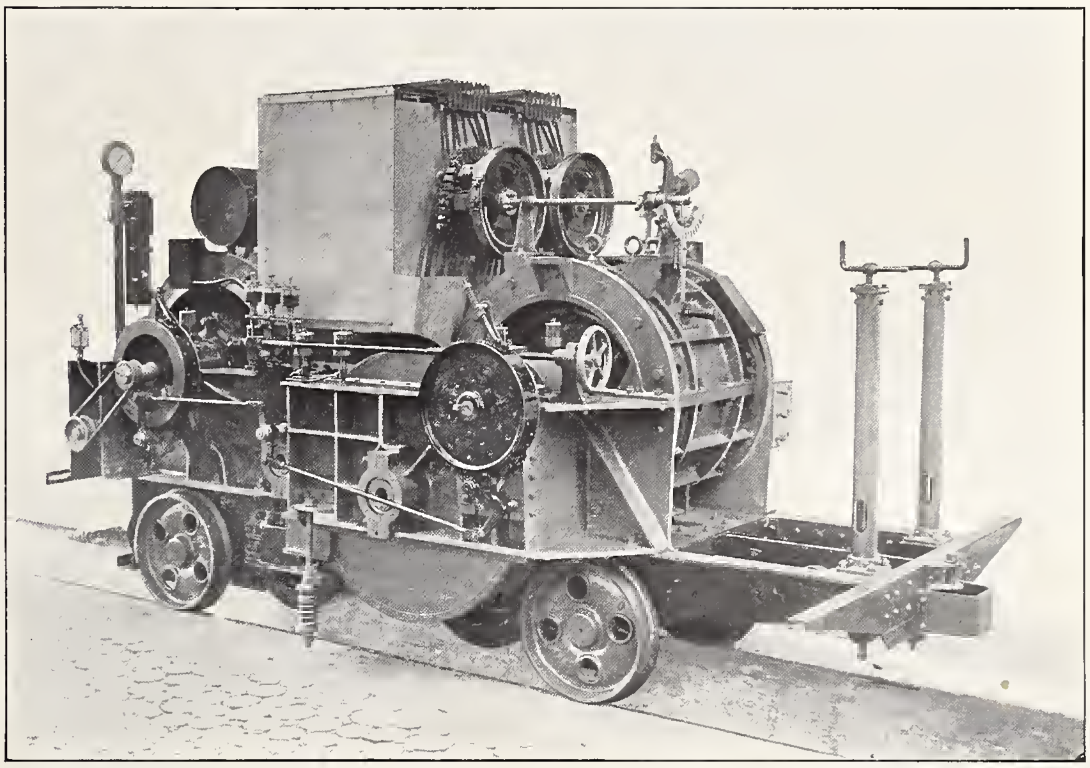


FIG. 5.—THE JUNGFRAU LOCOMOTIVE, WITH CAB REMOVED

FIG. 6.—THE INTERIOR OF ONE OF THE MOTOR CARS ON THE VALTELLINA RAILWAY

Messrs. Siemens & Halske was supplied with step-down transformers upon the car which reduced the pressure of the line from 10,000 volts to a lower tension for use in the motors. In the locomotive construction single-reduction electric motors are mounted on the trucks, and the current at 10,000 is used directly in the primary of the motors, no transformers being used on the locomotive.

The first car weighed about 192,000 lbs., and by the omission of the step-down transformers and other changes the locomotive weighs only about 150,000 lbs. The original car demonstrated the possibility of taking the alternating current at high potential from the line by collectors at high speed, and the three-phase alternating-current motor was shown to be well adapted for high-speed railway work, under severe continuous running.

In the first trials of the Berlin-Zossen line there was in operation, besides the experimental car of Siemens & Halske, another motor car equipment, constructed by the Allgemeine Elektricitäts-Gesellschaft, and this car also made some very high speed records. The capacity of the first car was about 1,000 horse power; on account of the reduced weight of the new locomotive, it is equipped with motors of only 920 horse power.

Although the locomotive was designed for four motors, two on each truck, only two motors have been used, one on each bogie. In a test at 11,000 volts pressure and a frequency of $77\frac{1}{2}$ cycles per second, and drawing a trailer car of about 62,000 lbs. weight, a speed of 62 miles per hour and over was attained, with an output of 280 horse power. The motors are controlled by resistances in series with the secondary windings. These have more than a score of steps, Krupp resistance wire being used, mounted on an iron frame and insulated with porcelain. The high-tension 10,000-volt circuits are connected to the primary windings of the motors through switches manipulated by pneumatic devices, all of the high-tension fuses, and contacts being placed behind a glass partition, but visible for inspection by the engineer. A step-down transformer of small size, located on the locomotive, supplies a current of 100 volts to an air pump three-phase motor, which furnishes the compressed air for controlling the switches.

The locomotive wheels are 4 feet in diameter. The motors operate at a speed of 885 revolutions per minute, so that if they were directly connected to the axle of the locomotive, as was the case with the first experimental car, the speed would be 124 miles per hour.

It was thought best, during the first experiments, to utilize single-reduction gearing with the ratio of 2 to 1, making the normal speed of the car 62 miles per hour. The motor armature is geared at both ends to the car axle. On account of the high peripheral speed of the gear teeth, a special oiling system was devised, using compressed air, as it was found that it was not sufficient to simply fill the gear-box with the oil and allow the gears to run in it. The pump drives the oil out of the reservoir to a distributing cock which forces it between the gears on one side or the other, according to the direction of the car, and after passing through the nozzles and lubricating the gear teeth, it is pumped back to the reservoir from the gear case. If the speed of the teeth were lower, this system of oiling would not be required, as with a ratio of 3 1/3 to 1 or 4 to 1, instead of 2 to 1, simply running the gears in an oil bath would provide ample lubrication.

The three high-tension wires or

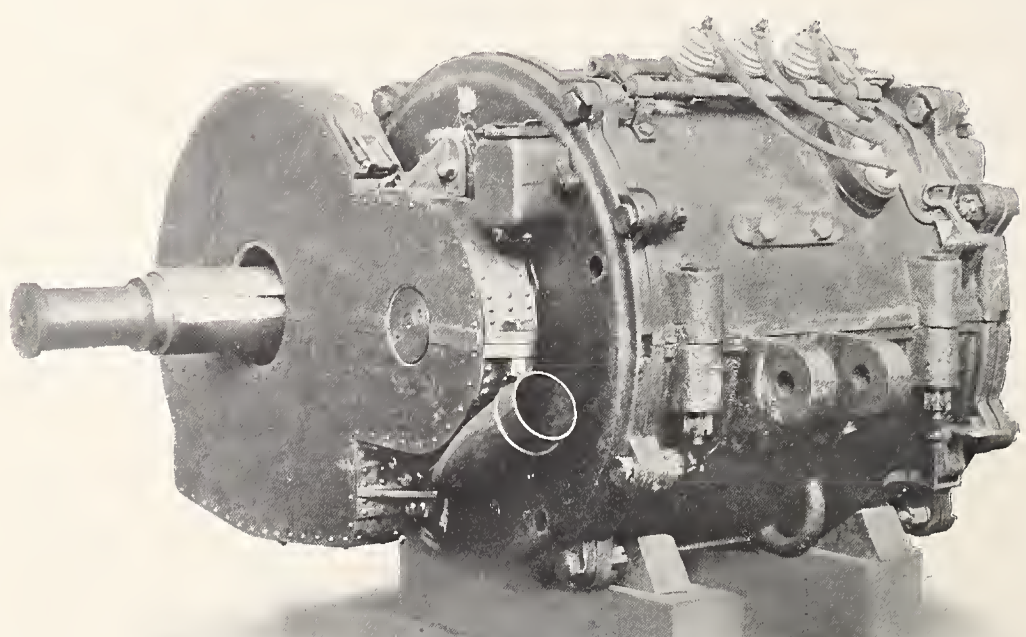


FIG. 7.—ONE OF THE THREE-PHASE 400 H. P. MOTORS OF THE SIEMENS & HALSKE LOCOMOTIVE, USED ON THE ZOSSEN LINE

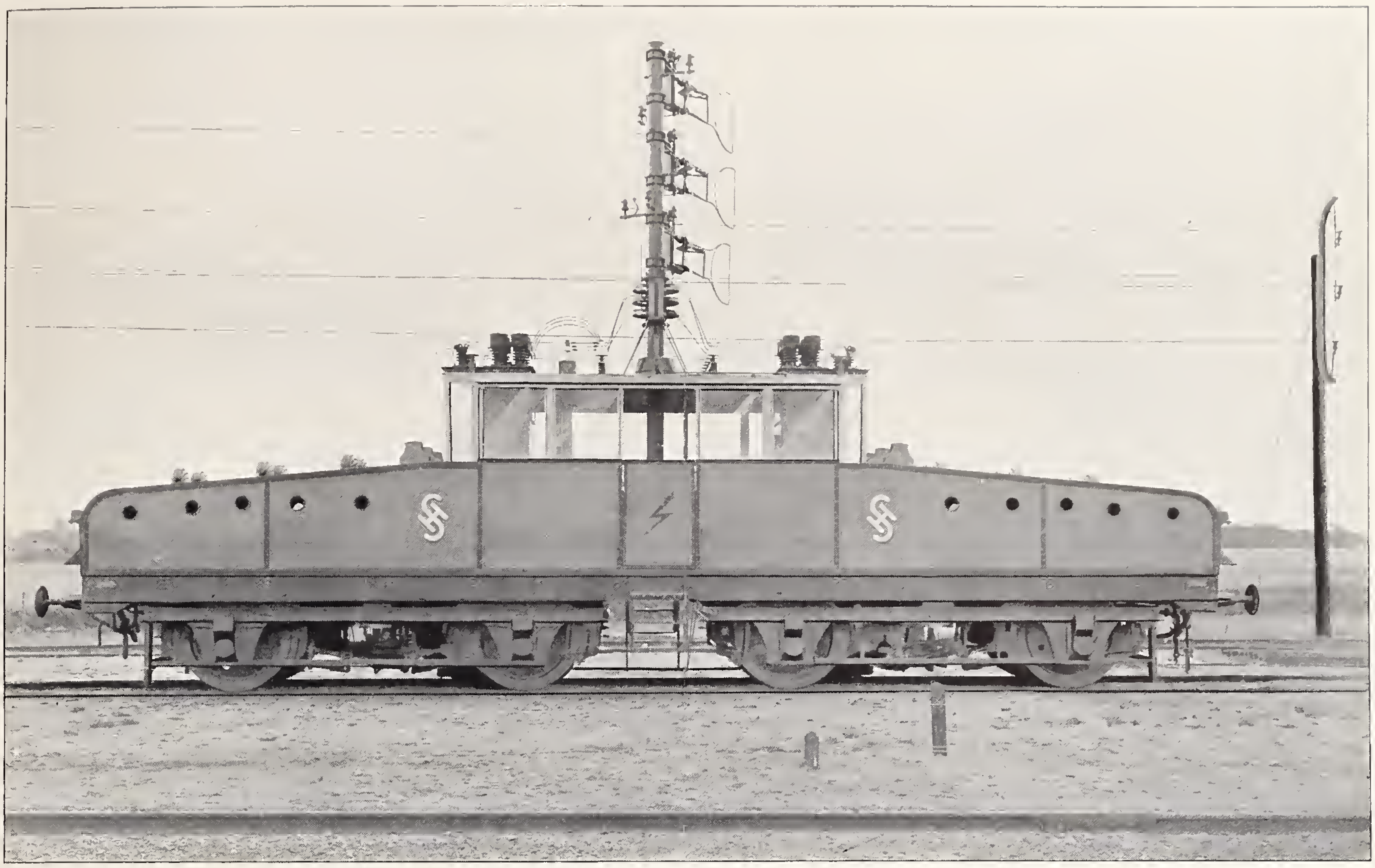


FIG. 8.—THE SIEMENS & HALSKE HIGH-SPEED ELECTRIC THREE-PHASE LOCOMOTIVE USED IN THE FAMOUS ZOSSEN TRIALS

cables to the primary terminals which are mounted on porcelain insulators, pass through both soft and hard rubber tubing and are tested to a potential of nearly double the working pressure. The motors and gears weigh about 4½ tons, the cases being constructed of steel castings in two sections, as shown in Fig. 7.

The Zossen line is nearly 15 miles long and has grades varying up to about 3 per cent. The line is divided into sections about half a mile long, with a feeder conductor connected to the center of each section. The poles are placed about 100 feet apart and about 8 feet from the track. The poles are of wood and have bow-shaped arms, with three hand-drawn copper conductors, arranged one above the other, supported upon hard rubber insulators which are, in turn, fastened to a vertical wire and chain suspension system. The lowest of these wires is about 20 feet from the ground.

The current is collected from the three overhead wires and conducted to the motors by a single upright mast of similar construction to those used on the original motor car. On this there were two masts, each having three bow-shaped collectors which pressed against the wires from the side. The mast passes down through the roof and may be revolved by the motorman through a set of gears.

Electric Plant Failures

Their Origin and Prevention

From a paper by A. C. Cormack, recently read before the British Institution of Mining Engineers

THE three tables given further on represent an analysis of the breakdowns which have occurred during the past four years with several thousand motors and dynamos, ranging in size from ½-horse-power (motor) to 800 kw. (dynamo). The machines included in these statistics work under conditions of attention and superintendence which are somewhat better than the average, and since a number of very bad machines have been left out of the count, the figures must be taken to be considerably above the average. Motors driving coal cutting machines have not been included, as the statistics from these are incomplete.

Table I. summarizes the nature of the accidents. When several parts were injured in a single breakdown, each is included in the table, excepting in those cases where the failure of one part is certain to follow on the failure of another. The points of origin of the different breakdowns are shown in Table II., and Table III. gives a summary of the ultimate causes of the failures. The per cents. in all cases refer to the total number of failures covered by the tables. The preparation of these tables has been somewhat complicated by the complex nature of some of the derangements. In some cases, the derangements were not caused by any single fault, and for this reason in preparing Table III. it was necessary to adopt a system of marks allocating the same number to each breakdown, but distributing them if more than one fault was the cause of breakdown.

Of the accidents in which the field magnet coils were damaged (Table I.), the larger number were cases in which the insulation between the coil, and the coil former or cores had given way. The 1.56 per cent. representing coils gone altogether—that is, arcing from series to shunt on the same coil or arcing between two separate coils —show that this is not altogether an uncommon accident. The latter accident is most frequently met with in bipolar machines, where the coils often touch. In this case, unless the outer layers are at the same potential, there is considerable risk of accident.

The failure of armatures constitutes by far the most serious item on the

table. The form which such failure most frequently assumes is the burning out of coils. In many cases the entire armature was burned out, and in others only a few coils. The percentage of coils gone to earth, 19.5 per cent., is also a large item, and most of these failures were due to destruction of insulation. The accumulation of dust or other matter on the insulating ridges, such as is met with at the end of the slot insulation or at the end of

Table I.—Relative Frequency with which Various Portions of Dynamos and Electric Motors were Damaged in Breakdowns.

	Per Cent
Mechanical Portions—	
Broken shafts	2.35
Binders and fasteners	9.40
Bearings	8.60
Other mechanical parts	4.70—25.05
Brush-gear, connections, terminals, etc.—	
Failure of brush insulation	2.35
Connections and terminals	3.10
Mechanical portion of brush-gear	1.56— 7.01
Field magnet coils—	
Coils burnt out	5.50
Coils earthed	3.10
Coils gone altogether	1.56—10.16
Armatures—	
Coils short-circuited and burnt out	29.00
Coils earthed (that is, failure of installation of frame)	19.50
Breakage of wire	15.60
Joint failures	8.60
Binders burnt	3.10
Driving horns	2.35—78.15
Commutators—	
Failure of insulation	10.15
Mechanical failures	10.95
Surface fusion	12.50—33.60

the coil supports of a barrel-wound armature, accounts for the majority of the remainder. Breakages of wire were confined mainly to the smaller sizes of wire-wound armatures, and usually took place at or about the points where the wires leave the coils or join the commutator. The joint failures are more common than they ought to be, although some were undoubtedly caused by short circuiting in another portion of the armature. The 3.1 per cent. in which binders were burnt are those cases where fusing took place by arcing between the binder and armature wires, and did not arise from purely mechanical stresses.

Commutators are frequently damaged, this having occurred in 33.6 per cent. of the breakdowns. The failures of commutator insulation have for the most part occurred at the ends, causing leakages to the earth-connected portions of the commutator or between bars or radial connections. In the majority of cases, these failures are caused by the presence of dirt, or other foreign matter, on the insulating ridges or between the radial connections. The mechanical failure of commutators, amounting to 10.95 per cent., consists of burst commutators, fracture of commutator lugs, and failure of keying of commutators. The cases where surface fusion of the commutator has occurred are cases where the surface of the commutator has been destroyed by violent sparking, sometimes between segments, the latter fault being the usual accompaniment of a broken wire.

Table II. is interesting as showing the parts of the machines which originated the failure. Breakdowns to shafts were caused generally by the armature coming out of center through wear of the bearings, so that the unbalanced downward magnetic pull added to the weight of the armature produced a severe bending movement in the shaft. These cases are properly chargeable to the bearings. An interesting defect in dynamo and motor bearings, which sometimes occurs and requires watching to prevent damage, is the wearing of the bearing upwards. This sometimes occurs in cases where the armature has been placed nearer the top ot the race than the bottom, in order that the upward pull of the magnets may relieve the pressure on the bearings. When the upward pull of the magnets is greater than the gravitational attraction, the bearings wear upwards, and allow the armature core to approach the pole tips when working. This, owing to its liability to escape detection, is a somewhat dangerous defect, for when the machine is examined at rest the armature clearance will appear satisfactory.

Most of the joint failures in wires are caused by bad workmanship. They have been, for the most part, confined to one or two makes of machines. Unfortunately, if a faulty joint is nicely finished outside, it is very difficult to detect until it causes trouble. This usually begins on the

Table II.—Points of Origin of Breakdowns. The Percentages Given Show the Frequency with which the Various Parts Caused Breakdowns.

	Per Cent
Mechanical Portions—	
Shafts	0.78
Bearings	8.60
General	1.65—11.03
Brush-gear, leads and terminals—	
Mechanical	3.90
Insulation	2.35
Leads and terminals	2.35— 8.60
Field magnets—	
Failure of coil insulation	7.80
Breakage of wire	0.78— 8.58
Armatures—	
Core and slot insulation	12.50
End insulation (that is, separating bridges)	5.50—18.00
Coil insulation	11.70
Joints	7.00
Fasteners and binders	1.65
Binder insulation	7.80
Driving horns	1.65—47.80
Commutators—	
Insulation	9.40
Fastening and keying	5.50—14.90
Starters	4.70
Unknown	3.13
Various	1.56

commutator surface. A number of joint failures are due to improper fastening of the commutator, but such have not been included in the percentage.

Commutators are responsible for 14.9 per cent. of the breakdowns, and these may be divided into two classes. The first, in which the insulation has broken down, most frequently occurs between the bars and supporting rings, the parts subject to the greatest difference of pressure. Such breakdowns often result in the burning out of the armature windings. To a much slighter extent breakdown of insulation between the segments occasionally occurs. This seldom results in more than a few coils being damaged. Only in a very few cases does a breakdown occur in the body of the insulation, permitting flashing through it. These few cases have all occurred where a material which absorbs moisture has been substituted for mica. Almost all the accidents to commutator insulation are due to the collection of oil, dust, etc., on the insulating ridges separating the segments from the clamping nuts. In many cases these ridges are made much too short. Sometimes there are no ridges at all, the insulation being flush or even sunk below the level of both bars and rings. The insulation at the outside end is usually most exposed to such accumulations, but being more easily cleaned fewer breakdowns appear to occur here than at the back end where cleaning is very difficult, sometimes impossible. Very few cases have occurred where insulation has broken down owing to the commutator wedging arrangements slacking back and permitting sufficient chattering to pulverize the insulation. This usually causes sufficient sparking at the brushes to draw attention to the defect before more serious mischief occurs. Defective fastening and keying of the commutator has caused 5.5 per cent. of the total number of accidents. Defective fastenings sometimes, although rarely, cause breakdowns of insulation, as described in the previous paragraphs. Bursting of the commutator by centrifugal force is not now so common as it used to be, and few cases are met with. As a general rule, the proportions of the parts are sufficient to resist the simple centrifugal stresses, and most of the bursts usually met with have been caused by improper locking arrangements. A cause of bursting of commutators which does not figure at all in this table is the bursting of the commutator owing to the bars being allowed to wear down too far. The defect or absence of keying of the commutators has caused in this class the largest number of breakdowns. When the keying is defective, the commutator is driven by the armature wires, and sometimes the commutator and the armature have slight relative motion on the shaft. This has caused a large number of breakages of the wires joining the armature to the commutator.

Starting switches of motors have been the cause of 4.7 per cent. of the

breakdowns in the table, and the writer may say that this figure has been kept low by timely alterations to a number of dangerous switches. A not uncommon fault in starters which has caused burning out of armatures is a breakage of the wire near the last stop. In such cases, a careless attendant occasionally continues the use of the starter, subjecting the armature to very heavy starting currents by applying practically the full voltage to a standing armature.

In this connection may be mentioned another very common fault which is found in starters for shunt motor—that is, taking the connection from the last stop of the resistance. This results in the voltage, applied to the shunt at the moment of switching on, being lowered to the same extent as the voltage applied to the armature, with the result that, to get the necessary starting torque, the full load current has to be much exceeded. The starting torque can be kept up by attaching the shunt wire to the first stop in the resistance. When the switch is in the "on" position, the current for the shunt requires to flow back along the resistance, but, as a general rule, this is a matter of little importance, and where it is desirable to arrange otherwise, an additional stop can be put in the switch to cut out this resistance after the lever has reached the last stop.

Table III.—Causes to which the Failures were Due.

	Per Cent	
Constructional—		
Bad design	18.36	
Perishing of insulation	7.40	
Bad workmanship	13.60	—39.36
Conditional—		
Overloading	1.37	
Over-rating	1.56	
Unsuitable	0.78	— 3.71
Maintenance—		
Dust and damp	7.40	
Rough usage	1.56	
Defective attention other than above	22.50	—31.46
Accidental and unavoidable, with reasonable care in construction and working		7.05
Unknown		13.10
Caused by faults in accessories		5.48

Table III. sets forth as far as possible the conclusions reached as to the cause of breakdowns. Some of the headings in this table mean practically the same thing, but it seemed desirable to make out separate categories. For example, the heading "Dust and damp" might have been merged in the "Defective attention" heading; but a number of breakdowns have been caused by dirt and damp that could hardly have been attributed to defective attention on the part of the attendant.

The first of the main headings, "Constructional defects," is responsible for 39.36 per cent. of the total number of breakdowns. With greater laxity in supervision, resulting in a greater number of breakdowns, this heading would probably have been a smaller percentage. A number of the defects in design, construction, etc., were known to exist when the machines came under observation, but they were usually of such a nature that little could be done to remedy them without entirely reconstructing the machines. Almost half of the 39.36 per cent. of the total failures were due to bad designs, 7.4 per cent. to deterioration of insulation under normal conditions of working. The writer looks upon this latter as bad design, because it is the use of unsuitable materials or of materials under unsuitable conditions.

Comparatively few of the faults were found in the mechanical portions of the machines. Those usually took the form of insufficient keying, bad arrangement of bearings, and other defects familiar to all mechanical engineers. The great majority of the faults in design appear to be in the electrical portions of the machines, and for the most part take the form of supplying too little insulation, insufficient insulating ridges, improper arrangements for supporting the conductors and their insulation. The writer is afraid that, owing to the stress of competition, a number of designers sacrifice, to a great extent, reliability to cheapness. Particularly in the case of small and medium sized motors the tendency is to design machines having higher rises of temperature than experience has shown to be compatible with reasonable durability of the machine. No margin appears to be left for the slightly abnormal conditions that almost every machine sooner or later meets with in its working life.

Damp and dust, 7.4 per cent., refers to those cases where a reasonable amount of attention was given to the machines by the attendant, but where, owing to unfavorable conditions, it was not possible to keep the machine sufficiently clean and dry to prevent trouble. Dust is frequently somewhat hygroscopic, absorbing quantities of moisture. Defects from dust occur most frequently in semi-inclosed motors. These are splendid automatic dust bins; the provision for cleaning usually is insufficient; many of them cannot be cleaned properly without being taken apart, and it would in most cases be impracticable to do this every time the machine required cleaning. The defects in semi-inclosed motors might quite well be attributed to bad design or unsuitability, but the writer leaves the reader to place it as he thinks fit, with the advice to adopt, where necessary, wholly inclosed motors, large enough to run cool; and easily accessible open-type machines in all other situations.

Electric Railway Equipment Tests at the St. Louis Exposition

According to an announcement just made by J. G. White, chairman of the Electric Railway Test Commission, it is desired, if possible, to perfect adequate arrangements for the conduct, at the Exposition, of a most comprehensive series of tests upon electric railway equipments in order that thereby a large amount of important scientific and engineering information may be compiled for the benefit and use of designers and engineers in meeting the great engineering questions now arising, which involve enormous expenditures and deal almost exclusively in the problem of electric railroading.

J. G. WHITE, CHAIRMAN OF THE ST. LOUIS ELECTRIC RAILWAY TEST COMMISSION

The Exposition has found it possible to provide adequate space in the Electricity Building for the installation of all modern systems for the operation and control of electric cars and trains. Exhibitors of such sets will be requested to so make their installations as to make these sets, through dynamometer equipments, available for test in position in the building.

On the grounds, the Exposition Company has provided special tracks, having an almost level grade and well ballasted, for the operation and test of such complete electric railway car and locomotive equipments as shall be offered. These special tracks consist

of two parallel sections of track fourteen hundred (1400) feet in length. In addition, terminal facilities will be arranged in a prominent location, capable of holding from twenty to twenty-five fully equipped cars.

The site of the special tracks is parallel with the Transportation and Varied Industries buildings, and between these buildings and Lindell Boulevard, which is the southern boundary of the pike. Another section of track on the Exposition grounds, consisting of two parallel tracks 2000 feet in length, will presumably also be available for the conduct of these tests, and arrangements are being made whereby, it is expected, the commission will have the use of additional experimental track about 3 miles in length outside of the Exposition grounds for the operation of the heavier equipments. It is believed that these tracks will afford ample space for very comprehensive tests upon all present types of electrically equipped cars and locomotives included in the following classes:—

EQUIPMENTS OPERATED FROM A CENTRAL STATION

(a) Cars equipped for city service.
(b) Cars equipped for interurban service.
(c) Industrial electric locomotives.
(d) Mining locomotives.
(e) Locomotives for steam railway service conditions.

EQUIPMENTS OPERATED BY STORED POWER

(a) Cars equipped for city service.
(b) Industrial locomotives.
(c) Mining locomotives.
(d) Locomotives for steam railway service conditions.
(e) Heavy tram service, electric automobiles.
(f) Heavy electric trucks.

The character to be given the tests made upon the various electrical equipments submitted may, it is thought, be divided as follows:—

TESTS ON APPARATUS IN ELECTRICITY BUILDING

(a) Tests on electric railway motor equipments under constant load to determine rate of heating during continuous operating.
(b) Tests on electric railway motor equipments to determine efficiency of such motors under different fixed conditions of operation.
(c) Tests on electric railway motor equipments for the purpose of determining their torque curves and accelerating power.
(d) Tests of hand, automatic and multiple-control systems to determine their relative economy, certainty and regularity of starting motor car equipments under fixed loads.

TESTS OF ELECTRIC RAILWAY EQUIPMENTS ON EXPERIMENTAL TRACK

(a) Acceleration tests on single cars and multiple equipped trains.
(b) Braking tests on single cars and multiple equipped trains.
(c) Coasting tests on single cars and multiple equipped trains.
(d) Motor heating tests on single cars and multiple equipped trains.
(e) Acceleration tests on locomotives and locomotive trains.
(f) Braking tests on locomotives and locomotive trains.
(g) Coasting tests on locomotives and locomotive trains.
(h) Motor heating tests on locomotives and locomotive trains.
(i) Tests to determine car and train friction.

In the matter of instruments and appliances for the standardization of instruments used in connection with the tests, it is announced that the National Bureau of Standards will erect, in the Palace of Electricity, a laboratory completely and fully equipped with every modern appliance needed for the most accurate and scientific standardization of all types and classes of electrical instruments, meters, etc.

The Reversing Electric Motor for Machine Tools

THE reversing motor, says "The Iron Age," is attracting much attention with makers of machine tools and seems destined to play an important part in the next stage of the development of the direct-connected motor - driven machine. A comparatively short time ago the electrical engineers discouraged an expressed hope that a reversing motor could be designed to give efficient service for this purpose, yet to-day several of the manufacturers of electrical equipment are furnishing one which, so far as tried, has given satisfactory results.

In an engine lathe, for example, a reversing variable speed motor gives the operator very complete control of his machine. In one lathe, not yet put on the market, a lever on the apron operates the reversing mechanism of the motor, causing it to act on the spindle with exceeding quickness, so much so that the spindle may be stopped within very narrow limits of the point desired, which may be a considerable factor in certain forms of thread cutting. Considerable cost is saved in the manufacture of a machine so equipped, it is claimed, because gearing necessary in procuring the reverse motion where the motor revolves in a constant direction is dispensed with. It is a sight that few machinists would fail to appreciate—a lathe spindle oscillating rapidly; in fact, as rapidly as the controlling lever can be moved back and forth by the operator. The reversing motor has not been tested sufficiently in commercial practice to establish its real efficiency, but it is a very interesting phase of machine tool development, and one that will doubtless be developed to complete efficiency if it has not already reached that point of perfection.

Popularity of the Steam Turbine

THE popularity of the steam turbine appears to be constantly increasing, and so-called new types are being steadily produced. According to "Engineering," every possible mode of working seems, however, to have been already patented in its main features by either Parsons, de Laval, or Ferranti, and the new types, on examination, generally turn out to be minor modifications of combinations of the work of these inventors, some of whose patents have, of course, lapsed with efflux of time. We note that even the ingenious minor modification in which the steam jet after leaving one wheel is reversed and turned back on to the same wheel, instead of being passed on to a second wheel, has already been devised by a number of independent inventors. The plan avoids the multiplication of wheels, but is such an obvious development that it is not surprising that the idea has been hit upon almost simultaneously by a number of independent engineers. It makes its reappearance in the new Terry steam turbine, and it constituted, it will be remembered, the novel feature of the Reidler-Stumpf turbine, and the idea was also patented in this country at the beginning of 1900 by a British inventor. In fact, every workable detail of a steam turbine appears to have been independently invented at various times and places, so that there is a fair prospect of good times for the patent lawyers in the course of the next few years.

It is very important that transformer oil should contain neither water nor acid. According to the "Road Section," a simple test may be made to detect the presence of water. Take a few crystals of blue stone (copper sulphate, Cu SO_4+5 H_2 O) and drive off the water of crystallization by roasting. To the white powder that is left add a small quantity of the oil to be tested. If the oil contains water, the powder regains its blue color. Acid may be most readily detected by blue litmus paper, which turns red when touched with acid.

Escalators and Traveling Stairways

By EDWARD VAN WINKLE, Consulting Engineer

THE word escalator was cleverly coined by an American elevator company and promptly copyrighted, which will prevent its universal use. It is well described as an Americanized offspring of both the Latin and French, and is derived from escalade (old French and French) meaning scale or climb, and scala (Latin) meaning ladder or stair. Thus with the suffix "tor" we get "the stair that climbs," or the climbing or traveling stair. About one hundred patents for such contrivances have been granted by the United States Government, some successful and more otherwise.

This form of elevator is designed for use at elevated railway and underground roads, retail dry goods stores, theaters, and all other places where the transfer of people with despatch from one level to another is necessary. It is easily realized that such an elevator, moving continuously, is admirably adapted for rapidly and comfortably elevating a large number of passengers through a one-story height.

The capacity of an escalator is dependent upon speed, which is normally 100 lineal feet per minute, and is not handicapped by intermittent and reciprocating motion as in the ordinary commonly known elevator. In general, the moving stairway consists of an endless inclined platform which moves at a uniform speed and upon which passengers step and are transferred from one landing to another. In addition to the platform, there is a moving hand rail which serves to steady the passengers in their ascent. The platform is made up of a series of iron sections, supported on rollers, linked together and running on tracks of various designs. The mechanism for operating the platform consists of two pairs of sprocket wheels, the teeth of which engage with link belts or projectors on sections as the case may be.

The Reno inclined elevator—one of several current types—is usually erected with an angle of inclination of moving platform of about 25 degrees, and consists of a continuous flat belt of iron sections, linked together with longitudinal ridges of rubber, which travel between the combed top and bottom landing plates. It will be seen in Fig. 1, that the foot of the passenger resting as it does upon the longitudinal ridges, will, when it arrives at the end of travel, be slid upon the combed landing, and the friction thus produced, forces the passenger involuntarily to step forward and thus make room for the person immediately behind him. The prongs of the landing are supposed to be carried down to the bottoms of the grooves between the ridges of the platform, and thus make it impossible for anything to be caught.

The duplex Reno stairway, shown in Fig. 3, was installed at "The May

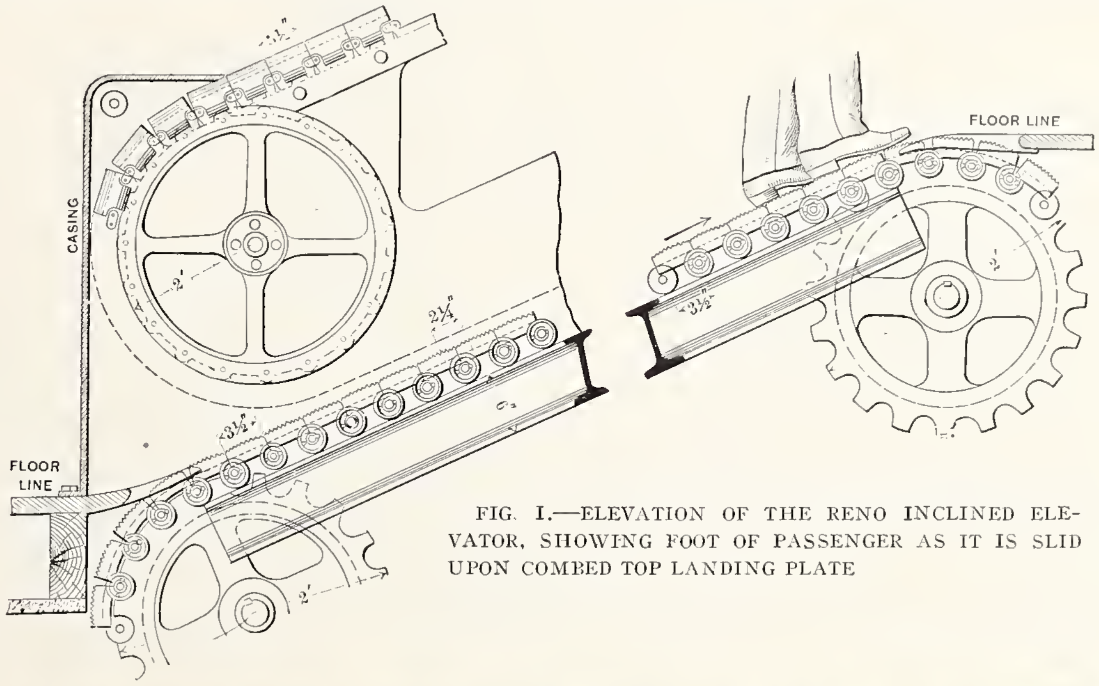


FIG. 1.—ELEVATION OF THE RENO INCLINED ELEVATOR, SHOWING FOOT OF PASSENGER AS IT IS SLID UPON COMBED TOP LANDING PLATE

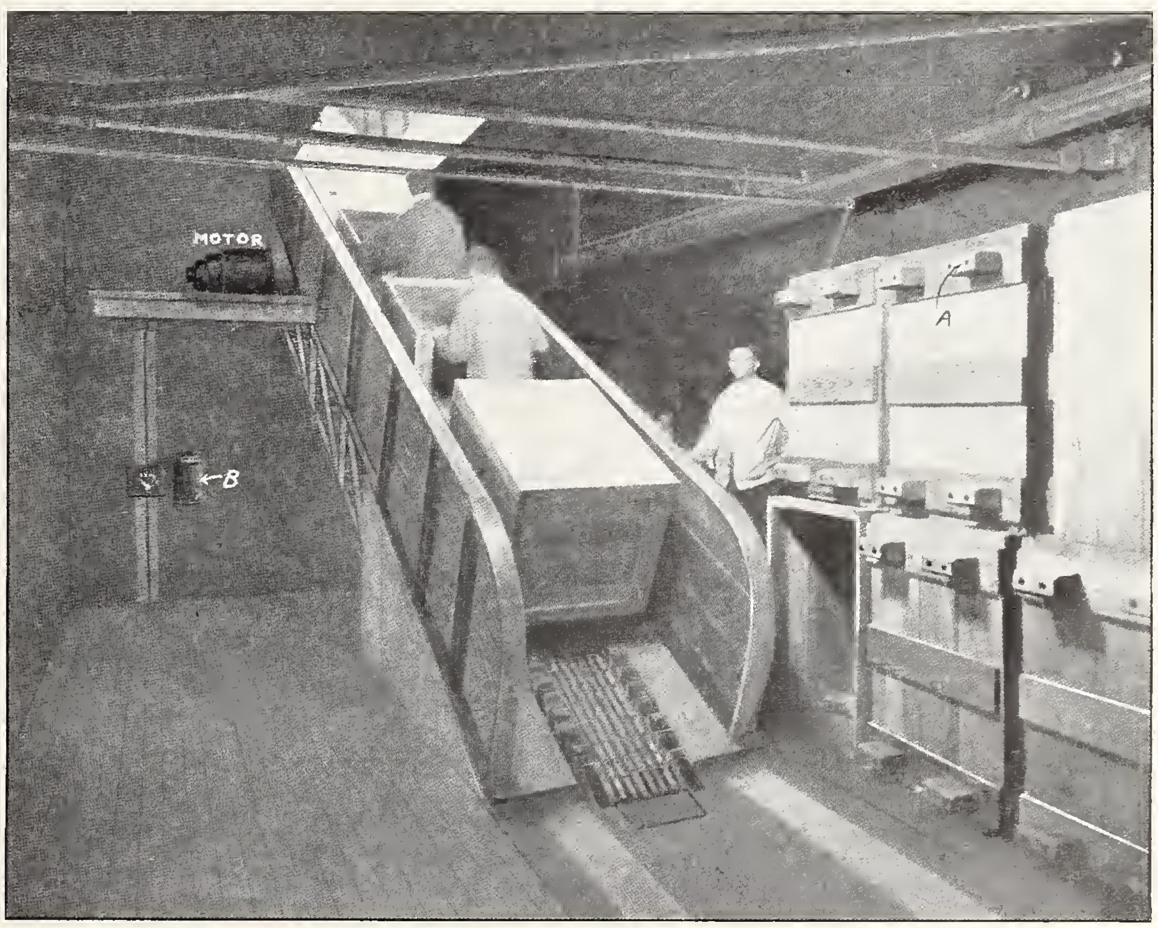


FIG. 2.—A RENO TRUCK ELEVATOR. *B* IS A REVERSING SWITCH, *A* ILLUSTRATES THE LUGS ON THE TRUCKS. MADE BY THE RENO ELEVATOR COMPANY, NEW YORK

FIG. 3.—A RENO DUPLEX ELEVATOR, CAPACITY 3000 PASSENGERS, ONE WAY, PER HOUR

Company" stores in Cleveland. The side on the right is used for ascending and the one on the left for descending. The weight of one belt counterbalances the weight of the other, and this is true likewise of the loads. Therefore, the weight of the passengers descending assists in raising the ascending passengers, and consequently the cost of operation is small.

Another familiar form of this type of moving stairway is illustrated in Fig. 2. This elevator consists of a moving incline, on the sides of each section of which iron lugs are bolted. These engage suitable iron projectors bolted to the bottom of the trucks or "wheelers." This elevator can be reversed if it is desired to bring trucks down to the lower landing.

The actual power consumed by one of the duplex traveling stairways now in operation in one of the largest department stores in the United States is best derived from the following readings:—

Conditions..
- Rise, 16 feet.
- Load, 3000 passengers per hour one way.
- Speed, 100 lineal feet per minute.
- Current, 230 volts.

Average Results..
- 9 amperes starting current (empty).
- 22 amperes maximum load, up only.
- 3 amperes maximum load, down only.
- 12 amperes average load, up and down.

For comparison with the one-way escalator to be described later, taking the maximum load on the up-side only, which is approximately $6\frac{1}{2}$ H. P., we have:—

$6\frac{1}{2}$ H. P. x 3 cents = 19.5 cents as cost of elevating 3000 passengers one way a distance of 16 feet, or 154 passengers elevated 16 feet at a power cost of 1 cent. One must not forget, in making the comparison, that the duplex moving stair, under ideal conditions, is very economical, as the average descending load counterbalances in part the average ascending load.

The Reno inclined elevator is claimed to be the most simple in construction of any escalator in operation at the present time. The disadvantage of this type of escalator lies in the fact that passengers are obliged to stand with their feet at an upward or downward angle of 25 degrees, which makes the passage uncomfortable.

The Hutchinson inclined elevator

is similar to the Reno with the exception that the sections provide a convenient surface for the feet of a passenger. It is based upon the fact that there is a neutral or common point located above the driving wheel and in the same vertical plane as the center of the driving wheel which may be utilized for the passenger's exit from the movable stairway because of the curved tread. This type presents many unnecessary joints which tend to cause annoyance.

The construction of the escalator as built by the Otis Elevator Company is clearly shown in the several illustrations. The angle of inclination is usually about 26 degrees. The steps are in the form of four-wheel carriages running on two sets of tracks so constructed that the treads are kept in a horizontal plane while in the usual vertical movement in passing from the lower to the upper landing. The front pair of wheels is not of the same gauge as the back pair, thus allowing the tracks to come up in same plane without interfering.

The carriages are linked together by a continuous chain which passes over the driving sprocket at the top landing. The chain is composed of two steel shrouds 18 inches long, placed 8 inches apart and connected by $1\frac{1}{2}$-inch steel pins spaced 3 inches between centers, thus forming a rigid link. These links are made male and female and form an endless chain. The hubs of the links have bronze bushings with a graphite inlay, and are, therefore, self-lubricating. The axle of the carriage is $1\frac{1}{2}$ inches in diameter and forms the connecting pin for the links, giving the chain a 3-inch pitch; it is not unlike a flexible rack passing over the driving sprocket wheel.

The standard step has a tread measuring 18 by 48 inches, and travels at the rate of 100 lineal feet per minute; thus 4000 steps reach the landing every hour. The treads are of quartered oak with the exception of the frame and risers. The average person is supposed to occupy 2 square feet, and as each step has an area of 6 square feet, it will accommodate three passengers; therefore, 12,000 passengers an hour can be carried.

As to power consumption, the readings for this type of moving stair were taken under identically the same conditions as were those for the Reno

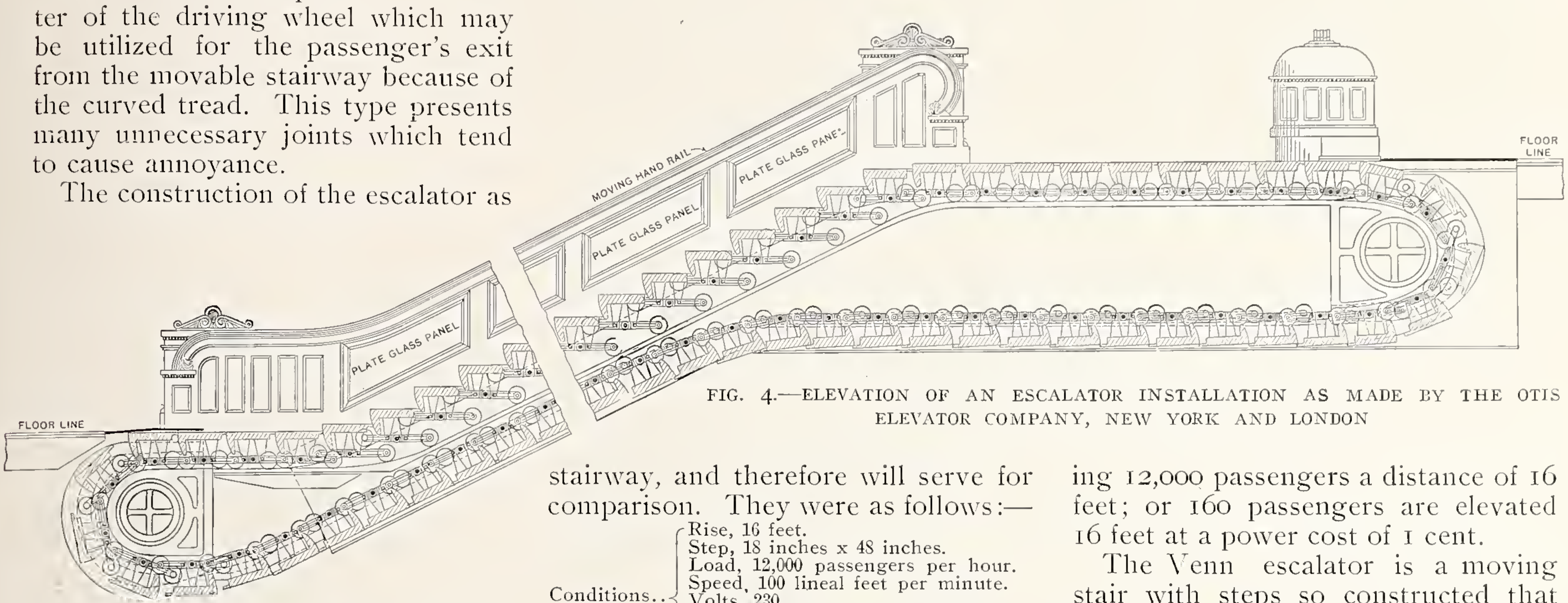


FIG. 4.—ELEVATION OF AN ESCALATOR INSTALLATION AS MADE BY THE OTIS ELEVATOR COMPANY, NEW YORK AND LONDON

stairway, and therefore will serve for comparison. They were as follows:—

Conditions..
- Rise, 16 feet.
- Step, 18 inches x 48 inches.
- Load, 12,000 passengers per hour.
- Speed, 100 lineal feet per minute.
- Volts, 230.
- 100 amperes starting current.
- 40 amperes running current (empty).
- 75 amperes running full load.

It will therefore be seen that from 30 to 35 H. P. are required in starting; 20 to 25 H. P. under full load, and 10 to 15 H. P. running no load.

Taking the H. P. with full load and multiplying by the cost of current, we obtain 75 cents as the cost of elevating 12,000 passengers a distance of 16 feet; or 160 passengers are elevated 16 feet at a power cost of 1 cent.

The Venn escalator is a moving stair with steps so constructed that each is supported at any one time upon two tracks with the use of only a single pair of rollers or bearing

FIG. 5.—AN OTIS ESCALATOR AT THE TWENTY-THIRD STREET STATION OF THE SIXTH AVENUE ELEVATED RAILROAD, NEW YORK

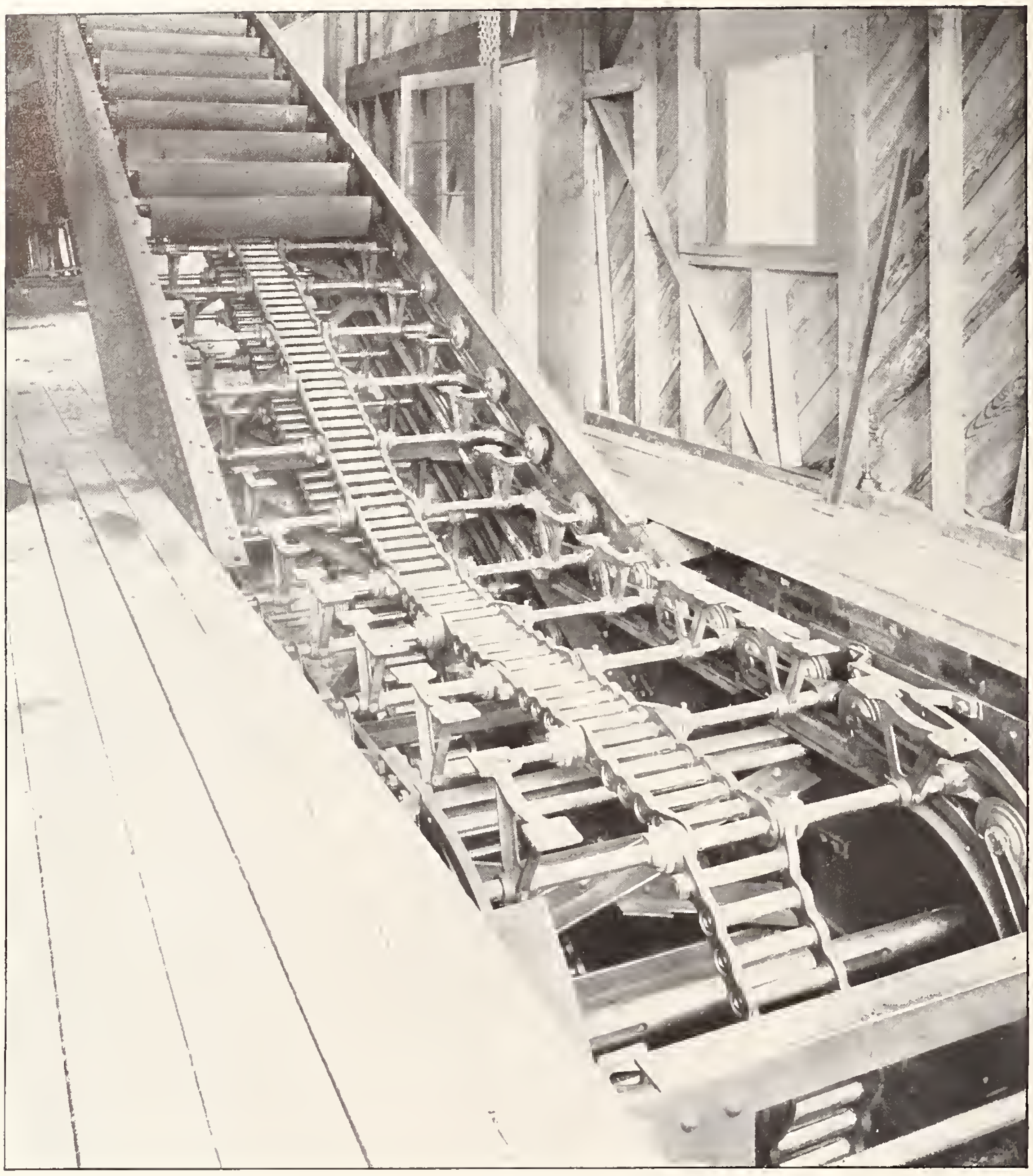


Fig. 6.—THE OTIS ESCALATOR RUNNING GEAR AROUND THE LOWER CARRIAGE. OBSERVE THE ASCENDING AND RETURNING RUNS OF THE SPROCKET CHAIN. THE TERMINAL WITH HORIZONTAL RUN FORMS THE LOWER LANDING

wheels. This system of construction avoids the necessity of additional tracks or roll support at each end of each step. The level of each step and of the horizontal bearing faces or treads is maintained, while permitting the usual vertical movement in passing from the lower horizontal to the upper landing, by means of two curved bearings upon the step with bearing points on the adjacent step and a link connection that will permit one step to move vertically independently of the other, while the curved bearing points maintain the steps in position vertically and prevent them from tipping.

This construction is cheaper, as there is but one set of tracks, and the carriage or step is simple, but this design has not as yet been practically tested.

To estimate approximately the power consumption for any escalator the following formula can be used:

$$H.\ P. = \frac{H + P \times W \times R}{33{,}000}$$

In this, $H = H.\ P.$ required to drive escalator, including hand rails.

$P =$ passengers per minute.

$W =$ average weight of passengers in pounds.

$R =$ rise in feet.

H for the Otis escalator is approximately 12 H. P.

H for Reno traveling stair is approximately 2 H. P.

H for Hutchinson traveling stair is approximately 3 H. P.

H for Venn escalator is approximately 10 H. P.

Only those traveling stairways have been described which have come prominently before the public. The escalator art is yet in its infancy and will probably not become extensive until a traveling stairway is designed so that the passenger, as he approaches it, is picked up without any volition on his or her part, and is deposited on the upper landing and on "terra firma" without elective preference, carrying with it no sensation which tends to frighten the nervous. That is the one great danger in connection with the different types of moving stairways built up to the present time, and the fact that each passenger has to step on to a moving platform from one that is still, and from a moving platform to one which is stationary, is a drawback which is acknowledged by the fact that an attendant, popularly known as "bouncer," is stationed at the top of every escalator now in operation.

Wireless Telegraphy in the Russo-Japanese War

REGARDING wireless telegraphy in Japan, with special reference to its uses in the present conflict with Russia, Mr. Chinooh Imay, formerly Japanese vice-consul at Montreal, is reported to have made the following statements:—"The wireless telegraph wizard of Japan is Dr. S. Kimura. He it is who has evolved Japan's wonderful system. In wireless telegraphy Japan is far ahead of even America. The Japanese nation took up its study as soon as it was announced, and no expense was spared in developing it. All of this was done with the idea of war in view. We have kept quiet all these years, excepting to make good use of our improvements, and I think we have succeeded. Our wireless telegraph facilities explain the seemingly wild reports of victories received at Tokio long before anyone else had heard of them. I know personally that the news of the attack on the ships at Port Arthur was sent to Tokio by the wireless system."

Russia has also been making use of wireless telegraphy, and has recently purchased an outfit of the Telefunken system for use in connection with the transportation of troops across Lake Baikal.

Platinum and its allied metals, which depend almost entirely upon the Ural Mountains for their crude supply, have already felt the effects of the Russian-Japanese War, owing to heavy withdrawal of forces from this mountain mining district by the Russian Government, the result of which has naturally been an advance in price. For some time there has been an increasing demand for platinum and its alloys in the electrical and chemical fields, which is constantly being supplemented by the increasing use of gas engines, automobiles and various new electrical appliances having platinum contacts and attachments. This growing demand, with a probable long continuance of the present situation in Russia, strongly points to a further advance in a very short time.

Insulating and Conducting Pins on Electric Transmission Lines

By ALTON D. ADAMS

INSULATORS may resist puncture and prevent surface arcing from wire to pin, but still allow a large though silent flow of energy over the pins and cross arms between the conductors of a transmission circuit. The rate at which current flows from one wire of a transmission circuit to another in this way depends on the total resistance of each path over insulator surfaces and through air to the pins and cross arm, and then over these parts.

If the pins and cross arm are entirely of iron, the total resistance of the path through them from wire to wire is practically that of the air and the insulator surfaces that complete this path. If the pins and cross arm are of wood which is dry, they may offer an appreciable part of the total resistance of the path through them between the wires of a circuit; but if the wood be wet, its resistance is very much reduced.

The resistance of wooden pins and cross arm may be so small compared with that of the air and insulator surfaces that complete the path through them from wire to wire of a circuit, that the effect of these wooden parts in checking the flow of current between conductors is relatively unimportant, and yet the relative resistances of these pins and the cross arm, or parts of them, as to each other, may have important results as to their lasting qualities.

The current that flows over the pins and cross arms from one wire to another of a high-tension circuit may be so small as not to injure these wooden parts when evenly distributed over them, and yet this same current may char or burn the wood if confined to a narrow path. Such a leakage current will naturally cease to be evenly distributed over pins and their cross arm when certain portions of their surfaces are of much lower resistance than others, because an electric current divides and follows several possible paths in the inverse ratio of their resistances.

These narrow paths of relatively low resistance along wooden pins and cross arms are heated and charred by the very current that they attract, so that the conductivity of the path and the heat developed therein react mutually to increase each other, and tend toward the destruction of the wood.

Among causes that tend to make some parts of pins and cross arms better conductors than others, there may be mentioned cracks in the wood, where dirt and moisture collect, dust, with a mixture of salt deposited on the wood by the winds at certain places, and sea fogs that are often blown only against one side of the pins and arms.

To make matters worse, the same cause that creates a path of relatively good conductivity along wooden pins and cross arms often materially lowers the resistance offered to the leakage of current by the insulator surfaces. Thus the rate at which energy passes from wire to wire of a circuit, and the concentration of this energy in certain parts of the wooden path, are sometimes brought about at the same time. Where the line insulators employed are so designed that the resistance of the dry wooden pins and cross arm forms a material part of the total resistance between the wires of a circult, a rain or heavy fog may cause a very large increase in the rate at which energy passes over these wooden parts between the conductors.

As long as only moderate voltages were carried on line conductors, the charring and burning of their pins and cross arms was a very unusual matter, but with the application of very high pressures on long circuits, the destruction of these wooden parts by the heat of leakage currents has become a serious menace to transmission systems. Even with low voltages there may be charring and burning of pins and cross arms if the line insulators are very poor, or if the conditions as to weather and flying dust are sufficiently severe.

In a recent volume of the Transactions of the American Institute of Electrical Engineers, an account of the charring and burning of pins on several transmission lines is given, from which some of the following examples are taken.

In one case a line that ran near a certain chemical factory was said to be much troubled by the burning of its pins, though the voltage employed was only 440, and the insulators were designed for circuits of 10,000 volts. In rainy weather, when insulators, pins and cross arms were washed clean of the chemical deposit, there was no pin burning. Similar trouble has been met with on sections of the 40,000-volt Provo line, in Utah, where dust, mixed with salt, is deposited on the insulators, pins and cross arms.

When circuits are operated at voltages of 40,000 to 60,000, no very severe climatic conditions are necessary to develop serious trouble in the wooden pins by leakage currents, even where the transmission lines are supported on insulators of the largest and best types yet developed. Striking examples along this line may be seen in the transmission systems between Colgate and Oakland, Cal., and between Electra and San Francisco. Both of these systems were designed to transmit energy at 60,000 volts, but the actual pressure of operation seems to have been limited to about 40,000 volts during most, if not all, of their period of service.

Insulators of a single type and size are used on both of these transmission lines, and are among the largest and most effective ever put into service on long circuits.

Each of these insulators is 11 inches in diameter, and 11¼ inches high from the lower edge to the top, the line wire being carried in a central top groove. The wooden pins used on the two lines vary a little in size, so that on the Electra line each pin stands 11½ inches above its cross arm, while on the Colgate line the corresponding distance is 12 inches. As the insulators are of the same size in each case, the length of the pin between the lower edge of each insulator and the top of the cross arm is 3½ inches on the Colgate line and 4 inches on the Electra line.

On the latter line a porcelain sleeve, entirely separate from, and making no contact with the insulator, covers each pin from the top of its cross arm to a point above the lower edge of the insulator. On the Colgate line each insulator makes contact with its pin for a length of $2\frac{1}{2}$ inches down from the top of its thread, and on the Electra line the contact of each insulator with its pin runs down $3\frac{1}{2}$ inches below the top of the thread. This leaves 9 inches in the length of the pin between the insulator contact and the top of each cross arm on the Colgate line, and a corresponding length of pin amounting to $8\frac{1}{2}$ inches on the Electra line. Of these $8\frac{1}{2}$ inches of pin surface, about 6 inches are covered by the porcelain insulating sleeve used on each pin of the Electra line, so that only about $2\frac{1}{2}$ inches of the length of each pin on that line are exposed to the leakage of current from the insulator directly through the air. Both the sizes of pins just mentioned were made of eucalyptus wood, boiled in linseed oil.

Each one of three pins taken from pole No. 4440, between North Tomer and Cordelia, on the Colgate line, was badly charred and burned on the side that faced the damp ocean winds. This charring extended all the way down each pin from the point where the insulator made contact with it, a little under the threads to the top of the cross arm, 9 inches below. Two of these pins were located at the opposite ends of a cross arm, and the third was fixed in the top of the pole. This cross arm was charred or burnt, as well as the pin, but no defects could be detected in the insulators that the pins supported.

As to these three pins the most reasonable explanation seems to be that enough current leaked over both the outside and inside surfaces of each insulator and through the air to char the pin and cross arm. In flowing down each pin, the current was naturally concentrated on the side exposed to the damp winds of the ocean, because the deposit of moisture by these winds lowered the resistance on that side. When these winds were not blowing, and before a pin became charred on one side, its resistance was probably about the same all the way around, and the leakage current, being distributed over the pin, was not sufficient to char it. The damp wind, would, of course, lower the surface resistance of each insulator, and this, with the deposit of moisture on the pins and cross arm, must have made a very material reduction in the total resistance from wire to wire.

The insulators used on these pins each had two petticoats, an upper one, 11 inches in diameter, and a lower one, $6\frac{1}{2}$ inches in diameter, the lower edge of the smaller petticoat being $7\frac{1}{2}$ inches beneath the lower outside edge of the larger petticoat. As the inner surface of the larger petticoat was much nearer to a horizontal plane than the inner surface of the smaller petticoat, moisture would have been more readily retained on it, and the greater part of the surface resistance of the insulator during wet weather must therefore have been on the inside of the smaller petticoat. At its lower edge the smaller petticoat was distant radially about $1\frac{3}{4}$ inches from the pin, and the distance between the pin and the inside surface of the smaller petticoat gradually decreased to actual contact at a point $5\frac{1}{2}$ inches above this lower edge.

The path of the current from the line wire to the pin in this case seems to have been first over the entire insulator surface to the lower edge of the smaller petticoat and then partly up over the inner surface of this petticoat and partly from that surface through the air. On each of these three pins the charring was quite as bad just below the thread as it was further down, so that a large part of the leakage current seems to have gone up over the interior surface of the smaller petticoat. The charred portion of these pins extended but little, if at all, into the threads near the tops or into the part of the pin fitting into the cross arm. The preservation of the part of each pin that entered the cross arm seems to have been due to the increase of surface and decrease of resistance of the cross arm in comparison with the pin. Preservation of the threaded part of each pin seems to have been due to its protection from moisture and its high resistance, so that little or no current passed over it.

Another pin taken from the same line as the three just considered was badly burned at a point about $1\frac{3}{4}$ inches below the threads, but on sawing it completely across at two points below the charred spot, the entire section was found to be perfectly sound and free from any sign of burning. The explanation of the condition of this pin is, perhaps, that the resistance of the burned part, owing to its additional protection and dryness, was high compared with that of the lower part of the pin, and thus developed most of the heat on the passage of current. It is not clear, however, why this pin should burn only just below the thread, while other pins of the same kind on the same line were charred all the way down from the thread to the cross arm. Another curious result noticed in some pins on this same line is the softening of the threads so that they can be rubbed off with the fingers.

RELATION OF PINS AND INSULATORS.

Location of line	Voltage of line.	Diameter of insulator. Inches.	Height of insulator. Inches.	Length of pin covered by insulator. Inches.
Electra to San Francisco	60,000	11	$11\frac{1}{4}$	12
Colgate to Oakland	60,000	11	$11\frac{1}{4}$	8
Canon Ferry to Butte	50,000	9	12	$10\frac{1}{2}$
Shawinigan Falls to Montreal	50,000	10	13	$10\frac{1}{4}$
Santa Ana River to Los Angeles	33,000	$6\frac{3}{4}$	$4\frac{7}{8}$	$2\frac{1}{4}$
Provo around Utah Lake	40,000	7	$5\frac{3}{4}$	$4\frac{3}{4}$
Spier Falls to Schenectady	30,000	$8\frac{1}{2}$	$6\frac{3}{4}$	$5\frac{1}{4}$
Niagara Falls to Buffalo	22,000	$7\frac{1}{2}$	7	5

The softened wood of the threads is not charred, but it is said to have a sour taste and to resemble digested wood pulp. While the threads of a wooden pin are destroyed in this way the remainder of the pin may still remain perfect and show no charring.

RELATION OF PINS AND INSULATORS.

Location of line.	Length of pin between insulator and cross arm. Inches.	Distance from outer petticoat to pin through air. Inches.	Distance from lowest petticoat to pin through air. Inches.
Electra to San Francisco	0	$10\frac{1}{2}$	3
Colgate to Oakland	$3\frac{1}{2}$	10	$2\frac{1}{2}$
Canon Ferry to Butte	$1\frac{1}{2}$	$7\frac{3}{4}$	$1\frac{1}{2}$
Shawinigan Falls to Montreal	$3\frac{1}{4}$	$9\frac{1}{2}$	1
Santa Ana River to Los Angeles	$3\frac{1}{2}$	$2\frac{3}{4}$	
Provo around Utah Lake	$3\frac{1}{2}$	$2\frac{1}{2}$	
Spier Falls to Schenectady	4	4	$\frac{5}{8}$
Niagara Falls to Buffalo	3	$4\frac{1}{2}$	2

In explanation of this disintegration of the threads of wooden pins it was stated that a number of these pins, the tops of which were reduced to a white powder, had been taken from the line between Niagara Falls and Buffalo, on which the voltage is 22,000, and that this powder proved, on analysis, to be a nitrate salt. This salt was thought to be the result of the action of nitric acid on the wood, it being supposed that the acid was formed by a static discharge acting on the oxygen and nitrogen of the air between the threads of the insulator and pin. In support of this view it was stated that an experimental line of galvanized-iron wire at Niagara Falls, which was operated at 75,000 volts continuously during nearly four months, turned black over its entire length of about two miles. This surface disintegration was not due to the normal action of the air, for similar wire at the same place remained

bright when not used as an electrical conductor.

These facts seemed to indicate that the brush discharge from the wires carrying the 75,000-volt current developed nitric acid from the oxygen and nitrogen of the air, and that this acid attacked the wire. If this explanation is correct as to the destruction of the threads on the wooden pins, it is not clear why only a very few insulators were punctured.

One of the above mentioned pins used on the Electra line was much charred and burned away at a point a little below the threads. The charred path of the current could also be traced down the side of the pin to the cross arm, but this path was not as badly burned as the spot near the top of the pin.

A composite pin from a 33,000-volt line, probably a part of the transmission system between the Santa Ana River and Los Angeles, was burned through its wooden threads to the central iron bolt, along a narrow strip at one side. Every pin burned on this line was said to show the effects of the current in the way just described, but no cross arms were burned and very few insulators punctured.

The composite pin was made up of a central iron bolt 10⅝ inches long, ½ inch in diameter and with a thin head above the wooden threads, a sleeve of wood 2⅝ inches long and 1 inch in diameter in its threaded portion, and a sleeve of porcelain 3⅛ inches long and 1¼ inches in diameter at its upper, and 2 11-16 inches at its lower end. The sleeves of wood and porcelain were slipped over the central iron bolt so that the portions of the pin above the cross arm measured 5⅞ inches. In this case the path of the leakage current seems to have been over both the exterior and interior surface of the insulator, and then through the wooden sleeve to the central bolt and the cross arm.

The facts just outlined certainly indicate a serious menace to the permanence and reliability of long, high voltage transmission lines supported by insulators on wooden pins. If such results have been encountered on the lines above named, where some of the largest and best designs of insulators are employed, it is only fair to assume that similar destructive effects of leakage currents are taking place on many other lines that operate at high voltages. Unless a remedy can be found for this destructive operation of leakage currents, the multiplication of transmissions at very high voltages will in some measure be checked.

It seems at least doubtful whether any enlargement or improvement of the insulators themselves will entirely avoid the destruction of their wooden pins in one of the ways mentioned. It is possible, but not certain, that further extensions of distances through air and over insulator surfaces, both exterior and interior, between line wires and wooden pins, will prevent charring and burning of the latter by leakage currents. Much has already been done in the way of covering most of the pin above its cross arm with the insulator parts, but even those portions of the pins that are best protected in this way are not free from burning.

Thus on the Colgate line 8 inches of each pin are protected by the interior surface of its insulator, but these pins were charred quite as badly where best protected, up close to the thread, as they were down near the cross arm. The same is true of the Electra line, where a porcelain sleeve runs up about the pin from the cross arm to a point above the inner petticoat of each insulator, so that the entire length of the pin above the cross arm is protected. On the Canon Ferry line, a glass sleeve that virtually forms a part of each insulator, though mechanically separate from it, protects the pin from its threaded portion to within 1½ inches of the cross arm.

Insulators on the line from Shawinigan Falls to Montreal are each 13 inches long and extend down over the pin to within 1½ inches of the cross arm. The burned portion of each pin from the Santa Ana line was that carrying the threads, and thus in actual contact with that part of the insulator which was separated by the greatest surface distance from the line wire. Aside from the burning of pins is the destruction of their threaded parts by some chemical agency that is developed inside of the tops of the insulators, as shown in the cases of the Colgate and Niagara lines. It does not appear that any improvement of insulators will necessarily prevent chemical action.

Though it may not be practicable to so increase the surface resistance of each insulator that the burning of wooden pins by leakage current will be prevented, the substitution of a conducting for an insulating pin may remedy the trouble. As the insulalators, pins and cross arm form a path for the leakage current from wire to wire, the wooden pins by their resistance, especially when dry, must develope heat. In pins of very low resistance and of non-combustible material, this heat would be trifling and would do no damage. With pins of good conducting material, like iron, the amount of leakage from wire to wire, with a given design of insulator, would, no doubt, be somewhat greater than the leakage with wooden pins.

It will be cheaper, however, to increase the resistance of new insulators up to the combined resistance of present insulators and their wooden pins than it will be to replace these pins when they are burned.

From all the evidence at hand, it seems that insulators which reduce the leakage of current over their surfaces to permissible limits as far as mere loss of energy is concerned, even with iron pins, will not prevent the charring and destruction of wooden pins.

When any suitable insulator is dry and clean it offers all necessary resistance to the leakage of current over its surface, and any resistance in the pin that carries the insulator is of small importance. If the resistance of an insulator needs to be reinforced by that of its pin in any case, it is when the surface of the insulator is wet or dirty. Unfortunately, however, the same weather conditions that deposit dirt or moisture on an insulator make similar deposits on its pin, and the resistance of the pin is lowered much more than that of the insulator by such deposits. The increase of current leakage over the surface of an insulator during rains and fogs usually does no damage to the insulator itself, but such leakage over the wet pin soon develops a surface layer of carbon that continues to act as a good conductor after the moisture that temporarily lowered the resistance has gone. Reasons like these have led some engineers to prefer iron pins with insulators that offer all of the resistance necessary for the voltage employed on the line.

It may be suggested that the use of iron pins will transfer the charring and burning to the wooden cross arms, but this does not seem to be a necessary result. The comparative freedom of cross arms from charring and burning where wooden pins are used, seems to be due to the larger surface and lower resistance of the cross arms. With iron pins having a shank of small diameter, so that the area of contact surface between the pin and the wooden cross arm is relatively small, there may be some charring of the wood at this contact surface. Should it be thought desirable to guard against any trouble of this sort, the surface of the iron pin in contact with the cross arm may be made ample by the use of large washers, or by giving each pin a greater diameter at the shank than elsewhere.

It may be noted that the pins with a

central iron bolt only half an inch in diameter, used on the 33,000-volt Santa Ana line, were said to have caused no burning of their cross arms in those cases where the wooden threads about the top of the central bolt were burned through.

Another possible trouble with iron pins, is that by their greater rate of expansion than glass or porcelain they will break their insulators. Such results can readily be avoided by cementing each iron pin into its insulator, instead of screwing the insulator onto the pin in the usual way. Iron pins will, no doubt, cost somewhat more than those of wood, but this cost will in any event be only a small percentage of the total investment in a transmission line. Considering the cost of the renewals of wooden pins, there seems little doubt that on a line where the voltage and other conditions are such as to result in the frequent burning, iron pins would be cheaper in the end.

Iron pins have already been adopted on a number of high-voltage lines. Not only iron pins but even iron cross arms and iron poles are in use on a number of transmission lines in Europe. On a long line now under construction in Mexico, it is understood that iron towers, placed as much as 500 feet apart, are used instead of wooden poles, and both the pins and cross arms are also of iron.

The Vancouver Power Company, Vancouver, British Columbia, use a pin that consists of a steel bolt about 12 inches long fitted with a sleeve of cast-iron 4½ inches long to enter the cross arm, and a lead thread to screw into the insulator. On the 111-mile line of the Washington Power Company, of Spokane, which was designed to operate at 60,000 volts and runs to the Standard and Hecla mines, a pin, consisting of a steel bar 1½ inches in diameter, with a cast iron shank 2 1-16 inches in diameter to enter the cross arm, and with the lead threads for the insulator, is used.

The network of transmission lines between Spier Falls, Schenectady, Albany and Troy, N. Y., is mounted on porcelain insulators supported by iron pins. Each of these pins consists of a malleable iron casting resting on the cross arm and carrying the insulator and of a wrought-iron or steel bolt that passes entirely through the cross arm and enters the casting.

Each insulator is secured to the cast top of the pin by pure Portland cement, which is poured into the pinhole in a liquid state while the pin is held in a central position. On some other lines a cement made of litharge and glycerine is said to have been used with good results.

On a long line designed for 60,000 volts, and recently completed in California, wooden pins are used with porcelain insulators, each 14 inches in diameter and 12½ inches high. Each of these pins is entirely covered with sheet zinc from the cross arm to the threaded end, and it is expected that this metal covering will protect the wood of the pin from injury by the leakage current.

A Belgian Electric Capstan

STEAM driven capstans as well as those operated by hydraulic power are now being replaced in many cases by electric capstans, on account of the greater economy as well as the greater convenience resulting from their use. The electric cables supplying the necessary power can be more easily installed in the yards and on the docks where capstans are usually employed than steam or water pipes, and the loss through condensation or leakage with these latter is considerable, while the steam engines and hydraulic motors used are inferior to the electric motor in economy of operation as well as cost of maintenance.

The accompanying illustrations show some details of construction of a new type of electric capstan installed by the Compagnie Internationale

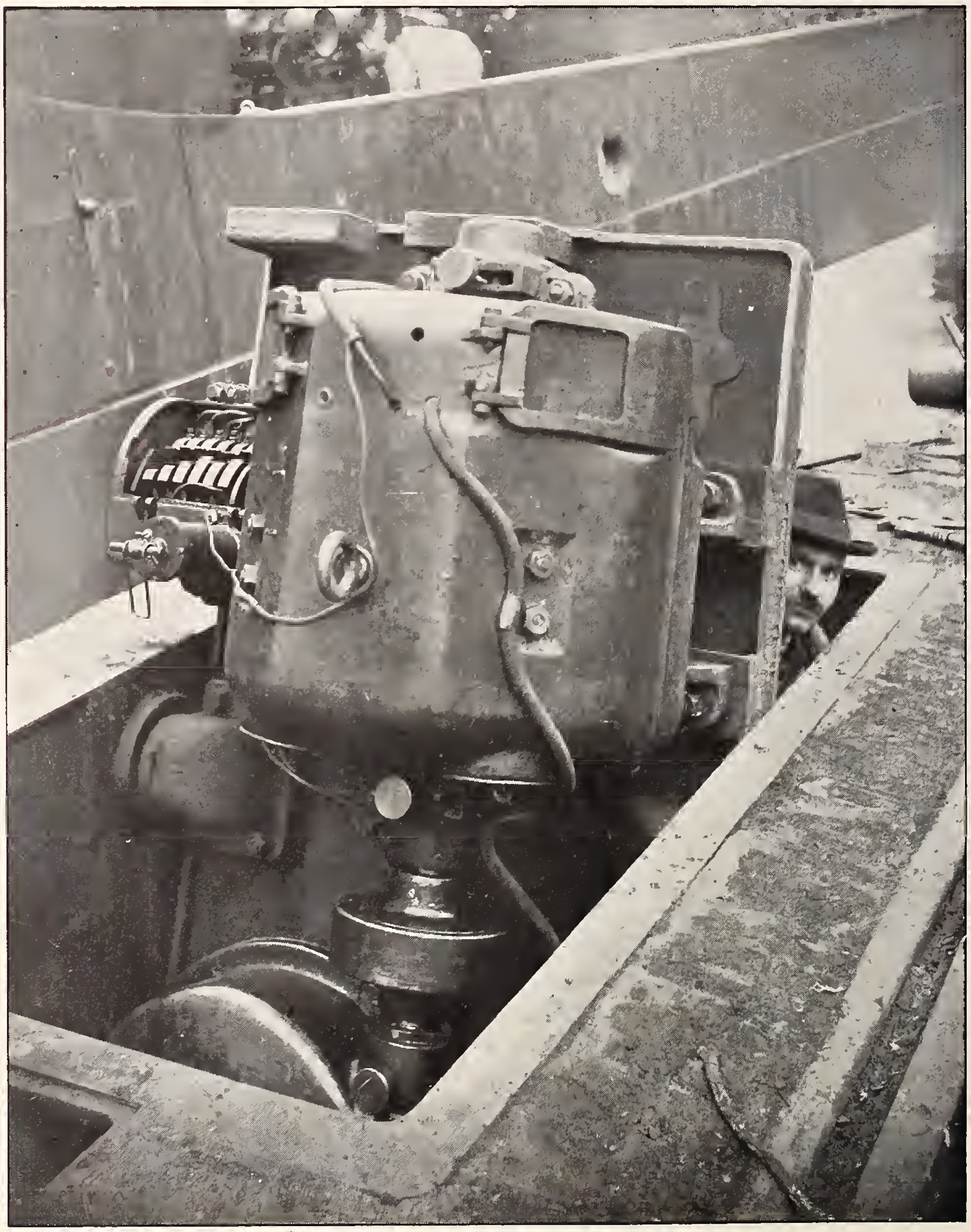


FIG. 1.—THE CAPSTAN BEING TURNED OVER FOR EXAMINATION

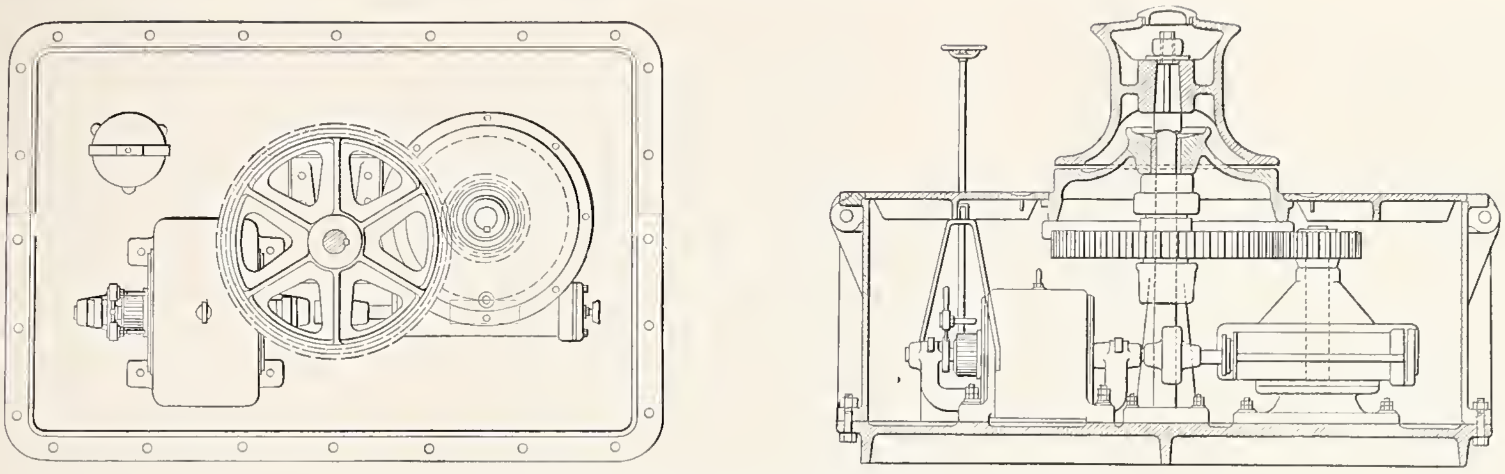


FIG. 2.—PLAN AND SECTIONAL ELEVATION OF THE CAPSTAN

D'Électricité, of Liège, Belgium, at the ports of Gand, Brussels, Ostende and Zeebruge. Fig. 5 shows one of the direct-current electric motors used for the operation of these capstans, while Fig. 4 shows one of the capstans mounted at one of the docks. Fig. 1 shows the electric motor, controller and capstan partially turned on end for ease of inspection, while Fig. 3 shows the apparatus entirely reversed, making the underneath parts easily accessible. Some of the details of the capstan are fairly shown in the plan and elevation given in Fig. 2.

The motor is of the compound direct-current enclosed type, of 22 horse-power capacity. The whole outfit occupies an area about $3\frac{1}{2}$ feet wide and $6\frac{1}{2}$ feet long, and is controlled by a treadle or a foot pedal as indicated. The motor is provided with a very efficient and positive electric brake which can bring the capstan to rest in one-fifth of a rotation. One of the most interesting and special features of construction of the device is its mounting on a horizontal axis, which allows the whole machine to be rotated through 180 degrees, as shown in Figs. 1 and 3, making it very convenient for examination or for the renewal of any of the parts of the motor, controller switch, or capstan mechanism. The capstans are particularly useful in railway freight yards as well as on docks. Four of these capstans have been installed by the "Administration du port de Bahia-Blanca" of the Argentine Republic.

The operation of the capstans is very simple. The current is switched on by the handle noted in Fig. 4 or the wheel shown in Fig. 2, thus supplying energy to the controller, which is operated by the foot pedal. Pressing down on the pedal moves the controller, a dashbot insuring the slow starting of the motor, and by releasing the foot pedal the electrical brake brings the capstan to rest within a fraction of a revolution.

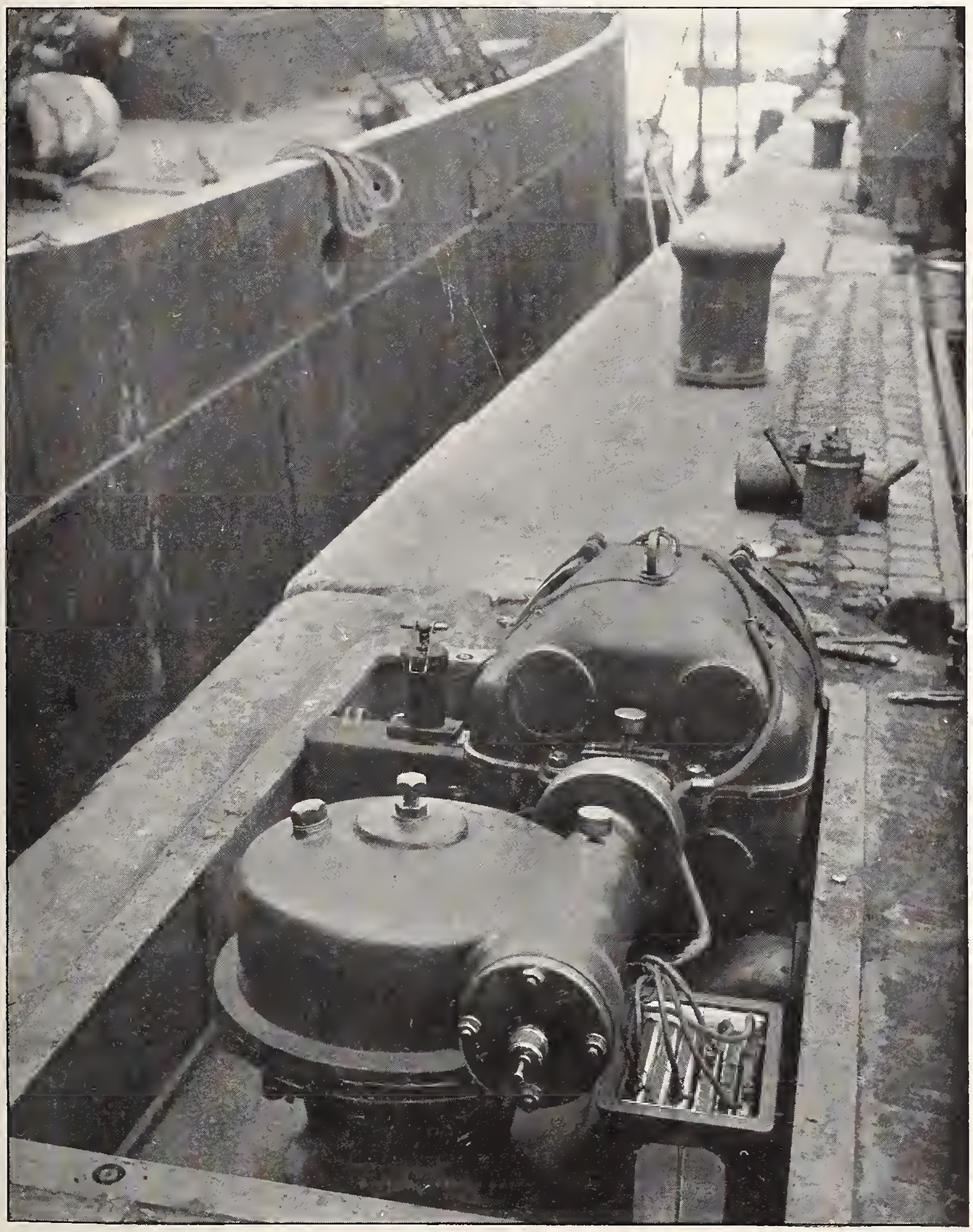


FIG. 3.—THE CAPSTAN COMPLETELY REVERSED

A British-Built Electric Railway for Canada

THE tender of Bruce Peebles & Co., Ltd., Edinburgh, has been accepted for an electric railway in Canada. This is, we believe, the first electric railway with a plant entirely of British manufacture to run in Canada. The railway runs through an agricultural district, the first portion of which—30 miles—extends from London, Ontario, through the city of St. Thomas to Port Stanley on Lake Erie. As soon as the line is energized the remaining portion from London to Hamilton will be electrified on the same system, making a total

4-6

FIG. 4.—A SERVICE VIEW OF ONE OF THE CAPSTANS

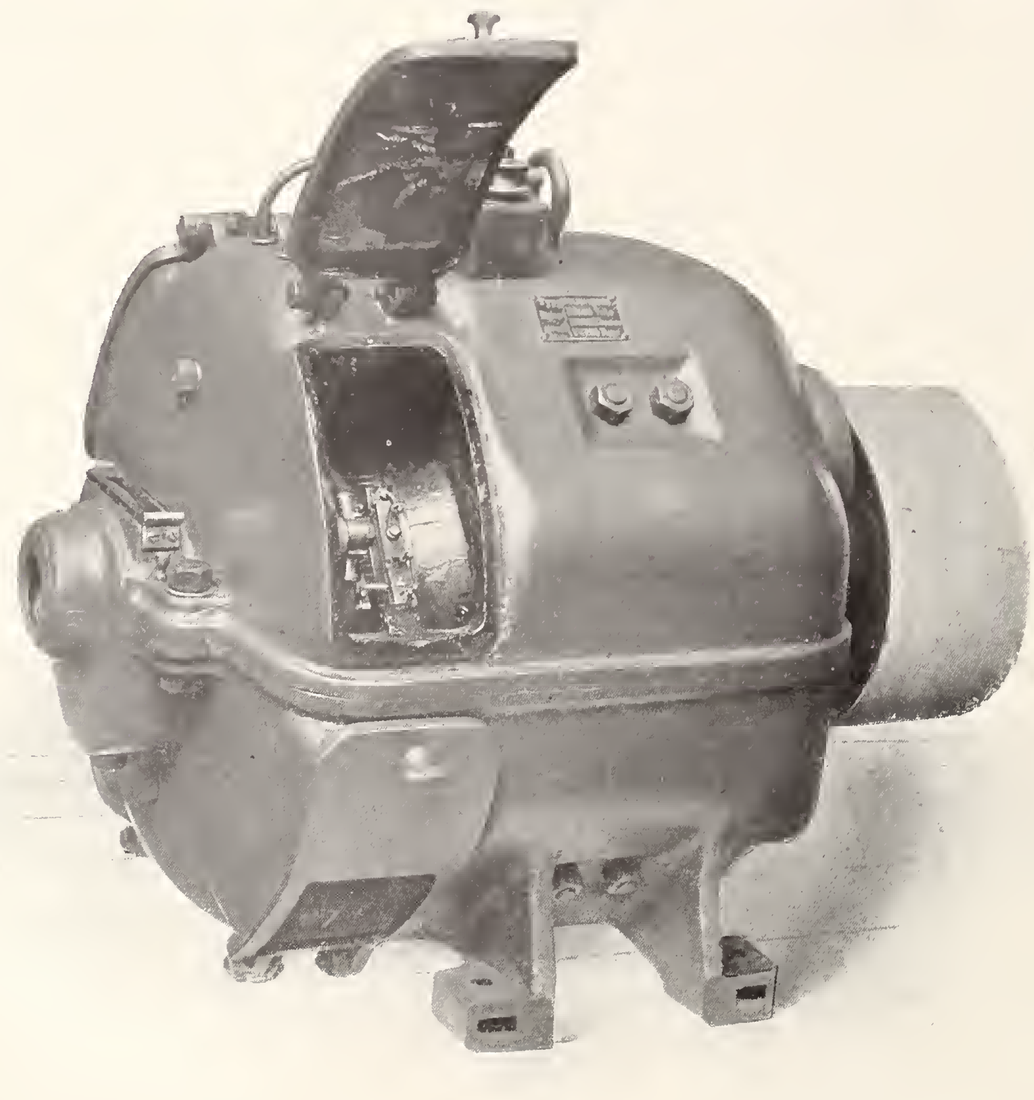


FIG. 5.—THE TYPE OF MOTOR USED

A BELGIAN ELECTRIC CAPSTAN

distance of 160 miles. The Ganz system has been adopted, as the makers hold that the guaranteed figures in comparing continuous current, single-phase, and three-phase estimates show a saving of 30 per cent. both in first cost and in running costs in the Ganz three-phase system. The power will be transmitted at 10,000 volts, 25 periods, and will be transformed down to 1000 volts for the motor-cars, of which there are ten, each motor car being designed to go at a speed of 30 miles an hour on the level and 15 miles an hour up grades of 1 in 25. Each car holds fifty passengers, and is capable of hauling either a freight or passenger trailer in addition. The line, says "The Engineer," is built partly across private right of way and partly across public roads, as is the case with urban railways in Canada and the United States, and the results in practice will be awaited with considerable interest, as the line is under contract to be completed six months from date. The whole of the electrical portion of the plant will be of British manufacture, built at Bruce Peebles & Co.'s works at Edinburgh. The amount of the contract is £42,500.

After months of litigation the State Supreme Court of Connecticut has upheld the constitutionality of the law providing for municipal ownership of lighting plants in instances where the citizens vote to purchase an existing private corporation. At the same time the court decided that the city of Norwich must buy the Norwich Gas & Electric Company at a cost of $590,000, plus the value of supplies on hand, this figure having been made by a committee on appraisal, or must pay the company $190,000 and leave the property in the hands of the bondholders. The amount of the bonds of the company is $400,000, secured by a mortgage. The value of the supplies on hand is about $20,000.

In a recent number of "The Car" it is announced that M. Bellamy, of Paris, has an automobile with the most powerful engine ever put on a motor car. The engine is 165 horse-power, with 8 cylinders and 3 forward speeds, the second speed being geared for 80 miles an hour. Last year it was thought phenomenal to put 100 horse-power engines on motor cars.

The United States Navy Department is making preparations, it is stated, to transfer the wireless telegraph school for enlisted men from Newport, R. I., to the Navy Yard at New York.

Underground Electric Cable Records

By W. E. RUNDLE

An engineer of an electric railway and lighting company in one of the large cities who was recently approached with a view to induce that company to purchase a license to use a plan for graphically recording its installation of cables, stated that it "does not need any such plan for this purpose." Shortly afterwards an investigation was made, during which a considerable amount of cable was found deadened either at one or both ends. Of the copper in this cable, about 10 per cent. were fit only for scrap, but 90 per cent. were not only ready for use but were also actually necessary to save a considerable loss in energy which had been and was then taking place, and their money value, leaving out of consideration any saving in power which would result from having the cable properly connected up, represented an investment of about $7000. The annual interest upon this alone, at 5 per cent., amounted to $350 a year.

With the present frequent changes in ownership or control of electric plants, comprehensive and accurate underground cable records become of increasing value. This is emphasized by the still more frequent changes which occur in the personnel of the engineering staffs of operating companies. Railway and lighting plants in large cities are growing rapidly, and owing to the replacement of overhead circuits by underground cables, underground cable systems are growing even more rapidly than generating plants.

When an engineer takes over the charge of a more or less complicated system with which he is not familiar,—especially an underground cable system,—it is impossible for him to obtain an accurate idea of the state of affairs as they then exist, without an expenditure of considerable time and money, unless accurate records have been filed by his predecessors.

In the case of the company referred to above, the value of the dead-ended cables involved only the taking into consideration of a small portion of the investment in copper, yet the loss in interest for one year upon the copper found was several times the cost of a license giving the company the right to use a graphic record system by which it would have been impossible to overlook the dead-ended cables. Such a plan has been adopted by several of the largest railway and lighting systems with underground cable installations, and is working to-day to their entire satisfaction.

The cable installation recording systems which are used perhaps more frequently than any others have usually comprised a file of manhole drawings or of card records. One of the largest electric railway companies in the country employs a comprehensive manhole drawing, showing the arrangement of ducts, the arrangement of cable hangers, the location of the cables in the ducts, the date on which the duct is rodded and wired, the date when the cable is installed in the duct, the number of the reel on which the cable is delivered, the length of cable installed to next manhole, the name of the jointer, the date of the joint, the kind of cable, if other than paper, the position of joints in the manhole and the position of the ducts. Another large electric railway company keeps most of such information on typewritten cards.

This information is shown on a drawing or on a card for each manhole through the entire system. Such records are good and are of great assistance. But these systems give data concerning only a single manhole, and in order to get the information desired, it may be necessary to examine successive drawings or cards, possibly of the whole system, comprising perhaps two or three hundred manholes, and, therefore, two or three hundred drawings or cards. Some form of record, preferably a graphic one, supplementing present records, giving the required data, for a block, a street, or for the entire system, is therefore obviously necessary and valuable.

The chart printed on the supplement sheet accompanying this issue gives in concise and complete form the following information:—A key map of the cable layout; the symbols used in the chart; the number of cables leaving the power house, together with their size, etc.; the duct which each particular cable occupies in each manhole throughout the entire length of the cable; the ducts unoccupied and the ducts occupied, and by what kind of cables. These last two items may be shown over any or all manholes desired, but should at least be shown over all manholes where cables leave power house or sub-station, or where a cable or cables diverge from a main group to another street or line.

The chart further indicates what cable has been ordered, but not forwarded; cable in town, but not laid; cable drawn into duct, with the number of the reel, the month, day and year, and the name of the foreman of the men drawing the cable into the duct; where two cables are in one duct; the number of manhole or name of cross street; the diameter of the manholes; distances between manholes; cable jointed, with month, day and year of the joint, and also name of jointer; switch pillars; pillars without caps; switch pillars with caps, together with date put on and name of man doing the work; and duct length or length of cable drawn into pillar.

Columns giving thickness of wall and character of insulation, the date on which specifications were issued and tenders were received, the date of contract, the name of the maker and desired additional like data may be placed on the left-hand side of the chart before the column "No. of Cable."

In the chart, the lines showing cable installation in various stages are all shown in black, as either solid or dotted lines. The locations of cables in ducts and the distances between manholes should be in red. For installation purposes, all cable ordered, but not forwarded, and all cable in town, not laid, should be in red also. The status of all installation work is thus readily discernible.

The chart shows an actual installation of the underground cable system of an electric railway company abroad. It will be noted, however, that cable No. 1 is the only cable completed upon the chart; the others are shown in various stages of installation. Sixteen cables in all are indicated as running from the power house through manholes Nos. 504 to 507.

From manhole No. 507 there are two branches, as indicated in the key in the lower right-hand corner of the chart. The first of these branches runs through Renfield street from

manhole No. 507 to manhole No. 514, where it again branches, one line running through New City Road (514 to 200, 201, etc.), and the other through Court street (514 to 100, 101, etc.). The second of the main branches runs through Great Western Road (507 to 800, etc.).

For laying out new cables, the form of chart illustrated, showing throughout the whole system from power house to termination, each and every change in the location of each cable in the ducts in each manhole, the ducts unoccupied in each manhole, the kinds of cable (i. e., low potential, high potential, telegraph, telephone, etc.) in the ducts occupied in each manhole, is of great value and saves much time in frequently going over the large number of drawings or cards heretofore employed and the assemblage of the data thus obtained, as well as avoiding mistakes in wrongly locating new cables. It is not expected that an engineer would knowingly locate a telephone cable in a duct adjoining another containing a railway cable of 11,000 volts, yet this may happen in locating such a cable of considerable length without the use of this chart, notwithstanding the assemblage of data from individual manhole drawings or cards.

By this system of record, a workman to repair a cable or change the location of certain cables does not require a drawing of any kind, designating the number or location of the cable or cables to be repaired or location to be changed, but can be instructed immediately and definitely by reference to this chart; a cable in a conduit in a manhole represented on the chart, as in Fig. 1 on this page, is located in the bottom row, center duct.

FIG. 1

Where feeders are taken off a three-conductor cable, for example, they are designated *a*, *b*, *c*, etc. If, therefore, a three-conductor cable leaving the power house be No. 7, the first feeder taken off becomes No. 7 *a*, from that point; the second, No. 7 *b*; the third, No. 7 *c*, etc.

A notable feature of this chart is that by its use a jointer who makes defective cable joints is readily detected, as on this chart a continuous record is kept of all joints made. If this record be kept by card or drawing, such a jointer's name may appear for some time on several cards or drawings unnoticed.

This form of chart permits of great flexibility and can be adapted to record information additional to that shown,

INTERBOROUGH RAPID TRANSIT CO.

DAILY DUCT THREADING REPORT.

DIVISION No. 1

Duct Nos.	M. H. Nos.	Location.	M. H. Nos.	Length.		Remarks.
11	1	23rd To 25th Sts	3	301'	0"	
11	3	25th " 26th St.	5	457'	0"	
		"				
		"				
		"				
		"				
		"				
		"				

Foreman.

Date, ... 190 Date, ... 190

FIG. 2

Interborough Rapid Transit Company

INSPECTOR'S DAILY CABLE REPORT

Date .... *190* ....

Date of Contract .... *190* ....

Name of Cable Company ....

Style of Cable ....

CABLE INSTALLED

M. H.	Div.	LOCATION	M. H.	Div.	Duct Nos.	Length of Cable		REMARKS
1	1	23 To 25	3	1	11	301'	"	
3	1	25 " 26	5	1	11	457'	0"	
		"						
		"						
		"						
		"						
					TOTAL	758'	0"	

.... INSPECTOR / FOREMAN } CABLE CO.

.... INSPECTOR I. R. T. CO.

FIG. 3

and cover practically any electric railway or lighting system. Charts may be made of any size of cross section, width, or length desired. The data above enumerated are reproduced on the chart accompanying this article, including the key, within a space 10 x 16 inches, and in it are graphically shown 32 manholes and 63,000 feet of cable. It is, therefore, apparent that most of the underground cable systems of the largest railway and lighting companies could be shown by this chart in the form of a wall map not longer than seven or eight feet.

The Interborough Rapid Transit Company, of the city of New York, uses this style of chart in the shape of a continuous map of its system. It is mounted upon rollers, within a glass case. The company's ducts are all located in the walls of the subway tunnel, 32 ducts high and 2 ducts wide, and instead of using a cross section of

the ducts over manholes, it numbers the ducts (squares) vertically, placing even-numbered ducts at the top of the chart and odd-numbered ducts at the bottom, and opposite each numbered duct draws in from time to time, between manholes, the cable installed in that duct, using red ink to designate a high-potential feeder, blue ink to designate a direct-current feeder, yellow ink to designate a lighting cable, green ink to designate a telephone cable, and brown ink to designate a tie-line cable. Fig 4 will help to explain this.

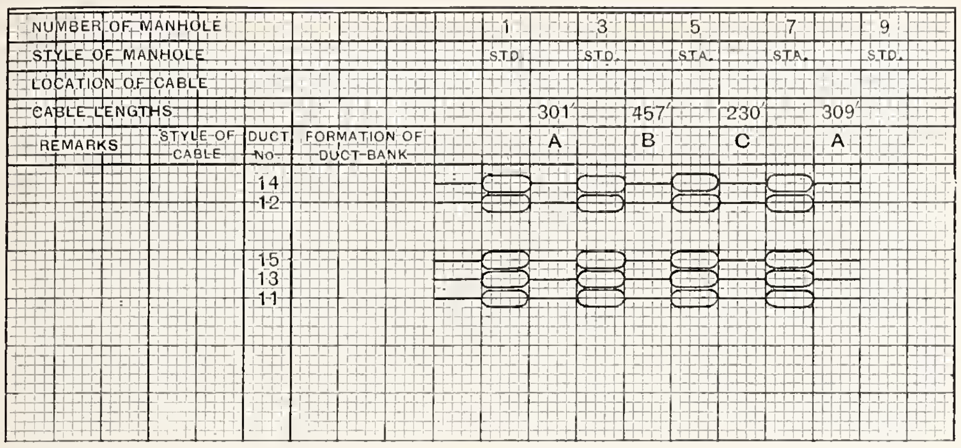


FIG. 4

As the ducts are threaded, the inspector of each section of the subway daily turns in to the chief inspector of cables the form of report shown in Fig. 2, which information is put upon the chart in dotted black pencil lines.

As the cables are installed, the cable inspector of each section of the subway turns in daily to the chief inspector of cables the form of report shown in Fig. 3, which information is put upon the chart in full black pencil lines. As cables are spliced, the inspector of each section of the subway turns in daily the form of report shown in Fig. 5 to the chief inspector of cables, which information is also entered upon the chart. When these records are checked by like information furnished by the company installing the cable, in the shape of bills for payment, the lines are inked in in the color designating the kind of cable installed.

Companies using this chart whose systems change considerably or frequently, however, will find it more convenient to keep such a record in book form of cross section paper of the section desired, of a size about 15 by 18 inches, leaving sufficient space underneath each cable to record, if necessary, several lengths which may be burned out, replaced, etc., and continuing the system on successive pages. The Niagara Falls Power Company keeps its cable installation record in such form.

The form of chart here illustrated has been adopted by every cable company of importance in this country which installs underground cables. It has also been adopted by some of the largest railway companies in New York City, London, and Baltimore, and by several lighting and power companies. It has been patented by the writer.

A peculiar accident happened recently to the electric plant of the city of Brantford, Ont. It appears that muskrats burrowed through the embankment skirting Lake Mohawk, whence the electric plant obtains its power, causing a large breach, which put the plant out of business.

INTERBOROUGH RAPID TRANSIT COMPANY

INSPECTOR'S DAILY CABLE REPORT

Date .... *190* ......

Date of Contract .... *190* ......

Name of Cable Company ....

Style of Cable ....

CABLE SPLICED

M. H.	Div.	LOCATION	Duct Nos.	Name of Splicer	REMARKS
3	1	25th St.	11	Smith	

.... INSPECTOR / FOREMAN } CABLE CO.

.... INSPECTOR I. R. T. CO.

FIG. 5

Electricity on a Modern Atlantic Steamship

THE new White Star Liner "Baltic," according to the "Scientific American," is probably better equipped electrically than any other boat either afloat or building. In addition to the usual electrical appliances to be found on board present-day ocean liners, the "Baltic" is equipped with an electrical device for preventing collisions with other vessels. The moment another ship enters the "magnetic field" of the "Baltic" the needle of the indicating instrument points in the direction of the vessel approaching or being overtaken, and the steersman knows at once what course to take. Even the rhythmic beats of an unseen steamer's screws are registered by means of this delicate apparatus. Another safeguard is an electrical contrivance to show if the ship's lights are burning properly. An electric log for ascertaining the speed of the ship is another acquisition, and an electric lead for ascertaining the depth of the water is also on the list. There is, further, an electric device for registering all signals, including steam sirens. The "Baltic" is equipped with electric refrigerating, as well as electric cooking apparatus.

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Sixty Years of the Telegraph

SIXTY years ago, on the twenty-seventh day of May, the historic message, "What hath God wrought?" was sent by telegraph from Washington to Baltimore, over an experimental line between those cities. This was the first telegraph message sent over a wire in this country. It is proposed to give recognition to this fact, and among other ways it is understood the Postal Telegraph-Cable Company will have a large family reunion in New York to celebrate fittingly the occasion. The historic message referred to was indited by Miss Annie Ellsworth, daughter of the Commissioner of Patents, at the request of Professor Morse in fulfillment of a promise made by him to Miss Ellsworth when she brought to him the unexpected, but exceedingly grateful, news that Congress had at last passed the bill appropriating $30,000 for the erection of the experimental line over which the message in question was transmitted.

The fact that a message had been thus transmitted, however, did not mean that telegraphy was now an assured success. The instruments employed at the time were, of course, very crude. The Morse relay at first used weighed 150 pounds. The Morse relay of to-day weighs less than 3 pounds. The key then used, which Morse called the "correspondent," was also a clumsy device compared with the modern telegraph key. The battery employed consisted of 100 Grove cells, which required renewal every three days. The messages were received by a large register which embossed the record on a paper strip.

To say also that the first message was transmitted on the 27th of May, 1844, does not mean that the line was then ready for business. In fact, nearly a year was spent thereafter in experimenting before the line was thought to be ready for service. For that matter, the public was not then ready for the telegraph, in evidence of which it may be stated that on the day the line was thrown open to the public, namely, April 1, 1845, and for four days afterward, not one message was offered for transmission. The tariff fixed by the Postmaster-General was 1 cent for every four letters or figures. From April 5 to April 9 the gross receipts of the line were $3.08½. Morse offered the line and its equipment to the Government for $100,000, but the offer was declined, which ultimately proved to be a fortunate thing for Morse and his colleagues from a pecuniary standpoint.

The system which had so small a beginning has in the sixty years since passed grown to such proportions that more than ninety millions of telegrams were transmitted on over one million miles of telegraph wire during the year 1903 in the United States alone, notwithstanding the amazing growth in recent years of the telephone—that sturdy rival of the telegraph, which already has in use three times as much wire mileage as is employed in the American telegraph service. Pages of eloquence will doubtless be employed in the forthcoming weeks in descanting upon the benefits of the telegraph to the world and its commerce, but it will perhaps be difficult to improve upon the simple and prophetic language contained in a report of the Committee on Commerce of the House of Representatives (April 6, 1838), which committee had investigated the claims of Morse for his telegraph system.

"It is obvious," said the committee, "that the influence of this invention over the political, commercial and social relations of the people of this widely extended country, looking to nothing beyond, will, in the event of success, of itself amount to a revolution unsurpassed in moral grandeur by any discovery that has been made in the arts and sciences, from the most distant period to which authentic history extends to the present day."

High Electric Railway Speed Problems

THE successful high-speed electric train service obtained in Germany and in this country, and the invasion of the steam railroad's special field of interurban service by the electric train, have brought electrical engineers face to face with some problems of a nature somewhat peculiar. In invading the field of interurban traction, the high speeds attained have not heretofore been so great as to question seriously the

limits of the work. Rapid transit service has come to stay, and to compete with any other motive power, electricity must increase rather than decrease the speed limit. Up to thirty miles an hour there are few of the important problems that make high speed a difficult question to consider. But in the recent experiments with electric cars running sixty, eighty, and even a hundred miles an hour, entirely new engineering problems have presented themselves.

One of these is the question of wind resistance. This becomes so important when the cars are running seventy-five miles an hour that it is likely to change the character of the service from single units to trains composed of several cars. Electric traction in cities and the suburbs has been superior to steam lines, partly because of the convenience afforded the public by single cars running at frequent intervals. But it is doubtful if this system can be adopted on high-speed roads. The wind resistance imposes such a heavy drag upon cars running above seventy miles an hour that the cost of operating them would quickly mount up to prohibitive figures.

The single car at high speed is handicapped. Two such cars running separately at short intervals require far more power to overcome the wind resistance than if the two were run together. Experiments have definitely shown that it requires much more power per ton to operate the single car than it does a train of several cars. The difference increases in proportion to the increase of the speed of the train. Thus at a speed of seventy-five miles per hour, it was found on the Buffalo & Lockport electric line of the International Railway Company, 47 watt-hours per ton per mile were required to run a train at this speed; but when single cars were operated the consumption of energy quickly mounted up to 137 watt-hours per ton per mile.

This enormous increase of energy to operate the single cars owing to the wind resistance must of necessity influence the future operation of high-speed electric railroad lines. Further experiments showed that this difference rapidly increased as the speed reached eighty and ninety miles per hour. Figuring upon this proportionate increase of power at a speed of one hundred miles per hour, the amount of power required to operate the single car system would be more than four times as great per ton per mile than that needed for running trains.

The reason for this is easily understood. The wind resistance attacks the first car, which must open a pathway through the air, and then set in motion the whole bank of air ahead. The difficulty of doing this at a speed greater than forty miles an hour is so great that half the expenditure of power is required for overcoming air resistance alone. The cost of operating high-speed trains and cars is thus used up chiefly in overcoming air inertia. The second car of a train does not have to set the air ahead in motion, and the only resistance it must overcome is what is called sliding friction. This grows proportionately greater as the speed of the train increases, but it never assumes such importance as the cutting through of the air at first.

In further investigations made with high-speed electric cars it was found that a train of six or seven cars coupled together could be operated at less expenditure of power than one of two or three. Up to a certain point the longer the train the greater was the economy of operation at any speed above sixty miles an hour.

The express electric service of the future must be speedy, clean and economical. To accomplish this, special tracks must be constructed for the express trains. The slower trains and freights must eventually use separate tracks, and the two services be kept entirely distinct. This is particularly manifest when the difference between the road beds of a steam railroad and an electric road is considered. The electric line cannot select a straight route, but it must wind around to accommodate the public. Even the express track must have many curves, and some of them will be too sharp for high-speed trains unless special provision is made.

This brings up another question of limiting the speed of electric trains. If curves are of necessity a part and parcel of the modern high-speed service, the matter of laying down the rails on an entirely different plan from that followed by the steam lines is quite urgent. The elevation of the outside rail on curves is in reality a simple matter, which can be reduced to a mathematical certainty. With proper elevation of the outside rail a speed of almost any degree can be accommodated. A train can run around a sharp curve at sixty miles an hour if the curve begins with a single degree and gradually increases to a maximum of five, ten and fifteen degrees, provided the outside rail is elevated so that the pull of gravity toward the inside of the curve balances the centrifugal outside pull.

The superelevation of the outside rail in curves is a subject that must be considered in constructing high-speed electric lines of the future, and it is possible on sharp curves to carry the track eight or more inches above the inside rail. The difficulty about such an extreme superelevation of the outside rail is that ordinary freight and slow passenger trains could not use the track without inviting some danger of toppling over. Any train running at a high speed could round the sharp curves without discomfort to the passengers, but a slow train might prove unequal to the task. Consequently, slow trains would have to be kept off the curves, and the express trains could not be stopped on them. The line would have to be so carefully controlled that delays should never happen at the curves. Probably the separation of the express service from the freight and local service might, after all, prove the most satisfactory in many ways in the end. There would be fewer accidents, and there would be an economy in operation.

The Cost of Water in Large Electric Power Stations

An item which might be thought to have been strangely ignored in the study of economies in large modern central steam-driven electric stations of 40,000 H. P. and more, is the cost of water. In most of the newer plants, even where surface condensers are employed in place of the latterly more popular jet condensers, the water of condensation is not used as feed-water, but is allowed to go to waste. With a fair average cost of water from a city supply and corresponding cost of coal and evaporative power, the cost of the water has been figured out to be a little over 10 per cent. of the cost of coal, and in the case of even a moderately large station this makes a tidy sum in the course of a year. In one large station recently completed, with a 100,000-H. P. boiler plant, the water bill has been estimated as likely to be in the neighborhood of $80,000 per annum.

The answer to the question why in these days of fine economies such a waste is permitted, is generally found in the expressed fear of oil being carried into the boilers with the condensed steam, and that thus far no satisfactory guarantee has been available that such condensed steam can be used over and over again without risk of boiler damage. The extent to which such fear is justified is not very clearly defined, but it might very properly be said that there ought to be no reason at all for its existence. Receivers, separators and filters for the condensed steam ought to admit of such combination and efficiency that they would be profitable invest-

ments in the value of water saved. Many small power plants certainly are known to save their exhaust steam, and are apparently having no trouble.

One argument that has been made in favor of wasting the exhaust steam in a large plant is that through it the construction and operation of the plant are simplified to a very considerable extent—that, in other words, the probable net saving in using the condensed steam over again would be so small as to make the installation and operation of any system of water-purifying apparatus an unwarranted expense. In a relatively small station of only a few thousand horse-power, it it maintained, it is possible, and it is probably good engineering, to go into all these refinements which promise to improve station economy; but when a station reaches 20,000 H. P. and more, it has been thought that the engineers in charge should have the simplest possible kind of station to operate, and a station of that size, built so that there is no likelihood that oil will reach the boilers, will be better operated than the one with the greater complication of machinery.

Underground Conduits and Electric Cables

FOURTEEN or fifteen years ago the matter of placing in underground conduits all the overhead wires that, with their supporting poles and cross-arms, were disfiguring the thoroughfares of many large cities, was a very vexed question, and in no other place was the matter so hotly contested as in the city of New York. In fact, it may be said that it was there that the battle was fought and won for underground conduits and cables. The chief opponent to placing the electrical wires underground in that city was one of the electric lighting companies, but that company doubtless represented and was backed by other electrical companies more or less equally interested from a financial standpoint. It is, perhaps, not to be wondered at that these interests, especially the electric lighting interests, were opposed to placing their circuits in cables underground, since it meant an enormous outlay for the purchase of cables to displace the overhead wires, and at the time in question the electric light companies were fighting for every inch of ground gained from their principal competitors, the gas companies, and were at best not earning any too large dividends to suit their stockholders. Besides, not only was there to be considered by the electrical interests the first cost of underground cables and the sending of their overhead circuits to the junk pile, but there was also the annual rental for the ducts in which the cables were to be placed in the subways, the cost of which was about $900 per mile per annum for a three-inch duct. The use of the streets for poles and wires had cost nothing. The disfigurement of the streets by the poles and wires was, however, so pronounced, and the fatalities due to contact directly or indirectly with the overhead wires were so frequent and at times so abhorrent, that public opinion almost unanimously supported the authorities in this action in compelling the placing of the wires underground, and ultimately the electrical companies yielded to the inevitable. The alternative was to go out of business, as the civic authorities, after many delays and warnings, finally cut down the poles and removed the wires from the streets.

Notwithstanding the expense incurred in operating electrical circuits underground there were many compensating advantages, chief of which was reliability of operation. With the overhead circuits there was never a storm, and, more particularly, never a sleet storm or a "blizzard," during and for days after which the city streets were not plunged in darkness, and as a result of which hundreds of miles of overhead wires were not completely crippled. Lightning storms also played havoc with the apparatus in the power houses, so that the approach of a severe storm by night or by day was a signal to those responsible for the operation of the circuits, wherever they might be, to prepare for the troubles which experience had shown was upon them. All this was changed with the burying of the wires, so that, apart from an occasional defect in an underground cable, the circuits operate uninterruptedly, day in and day out, totally regardless of weather conditions. Another frequent cause of serious delays in the operation of overhead wires in cities was the occurrence of fires, which very often necessitated the cutting of the wires. In contrast with this it may be noted that in the recent great fire in Baltimore the cables in the subways were quite uninjured, and a number of the through circuits in the conduits there have operated continuously, notwithstanding that tons of red-hot bricks were a few feet above them. In such a fire the poles and wires of an overhead system would have been utterly destroyed.

Recent experiments are understood to have demonstrated that the cause of thunder is to be found in the dissociation of water vapor.

The General Electric Company

THE annual report of the directors of the General Electric Company to the stockholders for the year ended January 31 last shows net profits of $7,865,376, including royalties and profit from securities sold and after allowing for depreciation. From this amount were deducted $76,007 for interest on debentures and $1,470,098 representing the amount written off from the patents and other accounts of the Stanley Electric Company, leaving a balance of $6,319,270. The dividends paid during the year were $3,508,284, and the surplus as of December 31 last, including the amount carried over from the previous year, was $7,293,688. On the general conditions governing the company's business the report says:—

"The disturbed financial and other unsatisfactory conditions of the past year have considerably affected your business, and the percentage of profit upon business done is smaller than for the previous year; the increased price of copper, higher priced and less effective labor, large expenses in developing steam turbines, and lower selling prices have all contributed to this result."

The balance sheet as of January 31, 1904, is as follows:—

ASSETS.

Cash	$3,289,445
Stocks and bonds	14,665,346
Real estate (other than factory plants)	424,082
Notes and accounts receivable	15,207,480
Work in progress	2,046,488
Merchandise inventories:—	
At factories	10,488,464
At general and local offices	1,247,754
Consignments	69,899
Factory plants	6,500,000
Patents, franchises and good will	2,000,000
Total	$55,938,961

LIABILITIES.

3½ per cent. gold coupon debentures	$2,049,400
5 per cent. gold coupon debentures	82,000
Accrued interest on debentures	683
Accounts payable	1,810,664
Unclaimed dividends	1,825
Deferred liability on account of purchase of Curtis turbine patents, payable in installments, up to February 1, 1906.	*834,000
Capital stock	43,866,700
Surplus	7,293,688
Total	$55,938,961

* The patent investment for which this liability was incurred has been charged to profit and loss.

Considerable attention is given in the report to the advantages of electricity as a motive power on railroads as compared with steam, and the interesting claim is advanced that "the popular apprehension of the 'deadly third rail' is without foundation as regards danger to the public—there is not a recorded instance of a passenger being killed by the third rail." The reduction in the operating expenses of the Manhattan Elevated from 55.8 per cent. in 1901, when steam was in use, to 44.7 per cent. in 1903, when the motive power was electricity, is instanced as a proof of the saving secured by a change from steam to electricity.

An Early Investigator in Electricity

Some of the Experiments of Francis Hawksbee, F. R. S.

By EDWIN J. HOUSTON, Ph. D.

IN these busy days so much of the time of the electrical engineer or investigator is necessarily employed in keeping up with the latest discoveries that comparatively little is left for a careful examination of the writings of some of the earlier investigators in this important field. At least this appears to be the general opinion. It is questionable, however, whether any one can afford to entirely ignore the investigations of the past, and this for several reasons.

In the first place, most of the earlier investigations were, to a great extent, made by minds that were absolutely unbiased by any preconceived theories or opinions. Of course, we are now alluding only to such investigations as were not made for the express purpose of sustaining some particular electric hypothesis or theory. Consequently, considerable advantage ought to be derived from a careful reading of investigations made under these circumstances.

In the next place, although this consideration is of especial interest to the investigator only, much valuable time would thus be saved in making investigations believed to be entirely original, but which, in fact, have already been made in the remote past.

Finally, and, perhaps, this is the most important aspect of the matter, a careful study at the present time of any unbiased investigations of a much earlier date, that are accurately recorded, possesses the marked advantage of being made in the light of all the knowledge that has been acquired in the electric sciences since the time that such investigations were made. Naturally, considerable light is thrown on many points that were, in the early days, obscure and apparently conflicting.

It is an interesting fact that some of the most important investigations in the electric field were made in absolute ignorance of the fact, at least during the early stages of the work, that the forces investigated were electric in origin. This is especially so in the case of Francis Hawksbee, curator of Expeiiments in the Royal Society of London. Hawksbee was a tireless investigator, mainly in the domain of physics. Some of his investigations were made in the field of electricity, although, strange to say, he appears, at least in his earlier experiments, to have been entirely unaware that the force he was investigating was the electric force.

The earliest experiments of Hawksbee of which we have any record are mentioned in communications to the Royal Society of London. These communications were made in 1705. Hawksbee had invented an excellent form of air pump, and was familiar with the phenomena of fairly high vacua. He had noticed, as others had done, the glow of light that was produced by the friction of the mercury against the inside of a dry glass tube from which all the air had been removed. As is now well known, this glow is electric in origin; but Hawksbee was not aware of this fact. He rather regarded the phenomenon as due to the presence of some variety or modification of phosphorus, and, therefore, gave to it the name of "mercurial phosphorus," because he believed that it was caused by some peculiar substance or quality in the mercury allied to phosphorus itself.

While Hawksbee was ignorant of the electric character of the light that was produced, his acute mind had no difficulty in seeing the resemblance it bore to the lightning flash. In one of his experiments he permitted the air to rush into a glass vessel containing a vacuum, the lower part of the vessel being sealed by dipping it into a mass of mercury. Raising one end of the vessel sufficiently to permit the air to rush into the vessel, he noticed that as it struck the sides of the glass vessel there appeared, to quote his language, "a body of fire consisting of an abundance of glowing globules." This luminous phenomenon continued until the pressure amounted to half an atmosphere. In another experiment he permitted about three pounds of mercury to fall in a vacuum from the top to the bottom of a receiver about 21 inches high. At the bottom of the receiver the mercury stream broke into a shower of fine particles that were dashed against a dome-shaped piece of glass placed in the lower part of the receiver. Under these circumstances, there were produced flashes of light, which, as Hawksbee says, resembled flashes of lightning. They were, indeed, miniature flashes of lightning, but Hawksbee was ignorant of this fact.

It is naturally a matter of surprise that an acute mind like that of Hawksbee's did not at once recognize the fact that the phenomena he was observing were electric in origin; for, as early as 1675, Boyle, with whom Hawksbee was acquainted, since he refers to him on several occasions in his communications to the Royal Society, had published some experiments and notes concerning the mechanical origin of electricity, and had noted the fact that warming increases the electric effects. Hawksbee, too, must also have been acquainted with Gilbert's great work, "De Magnete," published in 1600; nor could he have been ignorant of the globular electric machine produced in 1675 by Otto von Guericke, a contemporary of Boyle. Newton's experiments, communicated to the Royal Society in 1675, concerning the electrification of glass by friction, were also accessible to him.

But Hawksbee lived at a time when there was a prevalent belief in the existence of effluvia, or matter in a state of very fine division. He believed that the phenomena of "mercurial phosphorus" were caused by effluvia; nor, to a certain extent, was he so incorrect in this belief. He, therefore, permitted this conception to distract his mind from what he possibly saw at a later date; i. e., that the phenomena were electric.

Believing that the phenomena of "mercurial phosphorus" were due to the presence of some peculiar form of phosphorus or other allied substance, Hawksbee extended his experiments to a great variety of substances, all of which he believed contained either phosphorus itself, or some peculiar form of phosphorus. With this idea he extended his experiments to various solid substances which he thought might contain this substance. In

some of these investigations he made the following experiment with amber, which he describes on page 159 of the Philosophical Transactions, Vol. II., from 1700 to 1720:—

"Conjecturing, therefore, that Amber, which I took to be a Mineral Oleosum coagulated with a Mineral Volatile acid, might be a natural Phosphorus, I fell to make many Experiments upon it, and at last found that by gently rubbing a well polished piece of Amber with my Hand in the dark, which was the head of my Cane, I produced a Light; whereupon I got a pretty large piece of Amber, which I caused to be made long and taper, and drawing it gently through my Hand, being very dry, it afforded a considerable Light. I then used many kinds of soft Animal Substances, and found none did so well as that of Wool. And now, upon drawing a piece of Amber swiftly through the Woolen Cloth, and squeezing it pretty hard with my Hand, a prodigious number of little Cracklings were heard, and every one of those produced a little flash of Light; but when the Amber was drawn gently or slightly through the Cloth, it produced a Light, but no Crackling; but by holding one's Finger at a little distance from the Amber, a large Crackling is produced, with a great flash of Light succeeding it: and what, to me, is very surprising, upon its Eruption, it struck the Finger very sensibly wheresoever applied, with a push or puff like Wind. The Crackling is fully as loud as that of a Charcoal on Fire; nay, five or six Cracklings or more, according to the Quickness of placing the Finger, have been produced from one single Friction. Light always succeeded each of 'em. Now I make no Question but upon using a longer and larger piece of Amber, both the Cracklings and Light would be much greater, because I never yet found any Crackling from the head of my Cane, although it is a pretty large one; and it seems, in some degree, to represent Thunder and Lightning. But what is more strange than all I have told you is that, though upon Friction with Wool in the Daytime the Cracklings seem to be fully as many and as large, yet by all Trials I have made, very little Light is produced in the darkest Room."

* * * * *

"As Diamonds are Electral as well as Amber, I have made some Trials with them, and think my way of distinguishing Diamonds morally sure. A Diamond by an easy slight Friction in the Dark with any soft Animal Substance, such as the Finger, Woolen, Silk, etc., appears in its whole Body to be luminous; nay, if you keep rubbing it for a little while, and then expose it to the Eye, it will remain so for some little time."

In his search for substances, which, as he believed, contained some form of phosphorus, that would produce the phenomena of the "mercurial phosphorus," Hawksbee tried similar experiments with such substances as gum lac, sealing wax, pitch, and sulphur.

As will be seen from the preceding quotation, Hawksbee conducted at this early date a fairly extended series of experiments on the electrification of amber, sulphur, gum lac, sealing wax, pitch, etc., without apparently having any idea that the phenomena were electric. Indeed, as we will now show, he produced a globular electric machine similar to that produced at a previous date by von Guericke in 1675; that is to say, an excellent form of electric machine was produced, not for the express purposes of an electric machine, but simply for evolving luminous phenomena produced by the so-called mercurial phosphorus under conditions resembling that of mercury in a vacuous space; i. e., of subjecting a rotating globe of glass to the friction of the hand on the outside. The inside of this globe was coated with some of the materials in which Hawksbee believed some form of phosphorus to exist; i. e., sealing wax, sulphur, or pitch, and at the same time maintaining a high vacuum inside of the globe.

Hawksbee describes these experiments in a communication to the Royal Society, as follows:—

"This Experiment affords a singular Confirmation of another formerly made, and differs only in the Matter made use of. I before used Sealing-Wax, but now made choice of Pitch, which I served as the Sealing-Wax; that is, I melted it in Globe-glass, and kept it turning until the larger half had got a pretty thick lining of it; it was even so thick that a Ray of Light could no way penetrate it. This Globe I exhausted of its contained Air; then (being Night) I put it on the engine to give Motion to it; where, after it had been turned a little while with my Hand on that half lined with the Pitch, I could very easily discover through the transparent Part, on the inward Surface of the Pitch, the very shape and the Lines of it, as likewise of my Fingers, for the most eminent Parts of the Hand and Fingers that toucht the Glass appeared all luminous. The other Parts discovered themselves by the dark Intervals they made between the enlightened Parts; and when the Fingers were spread or closed, 'twas very obvious to the Sight. Now after a small quantity of Air was let in, the Light disappeared on the inside of the lower Part (but not on the other) which began to discover itself more and more on the outside; tho' even in vacuo there was always a Light attended on the touch of those Parts that were most contiguous to the Glass. But now such a Circle of Light would discover itself on the edge of the Pitch which separated it from the transparent Part, as, likewise, another Ring of Light somewhat nearer to the Axis of the Glass, but both these appeared when the Hand was applied to the under Part; for when it was removed, on the contrary, no such appearance ensued. The transparent half of the Glass was, in all Circumstances, as in the former Experiments. When all the Air was let in the Electricity of the Glass in all its Parts, the lined as well as the transparent, were formed much alike. The Threads seemed to be attracted everywhere with equal Vigour. To conclude, this and the fore-mentioned Experiment of the Sealing-Wax plainly discover a transparent Quality in some Bodies (we call Opake) under such and such Circumstances. Bodies which are really Opake have hitherto been thought to continue always so. It was never so much as suspected, that they could exchange that Quality for the contrary one, and then come back from that contrary one to their old State again; That they should pass from Opake to Pellucid, and from Pellucid to Opake; at one time admit, and at another time oppose the Passage of Light; and all this by a mere change of external Circumstances. This Property, I say, is as new as 'tis real and surprising: and bare consideration of so unlikely and unexpected a thing, may be a ground of encouragement to hope that soon other odd properties of Bodies by some lucky Tryals may hereafter (as this has done) surprise us with the discovery of Themselves."

Hawksbee repeated the above experiment, employing melted sulphur in place of the pitch. The results he obtained from this substitution he describes as follows:—

"I took a quantity of common Sulphur, nearly equal to what I had used before, of the Flowers; which, having melted as before, I poured it into another Glass Globe, which I used in all Respects as the former. But when I had exhausted it, and given the usual Motion and Attrition, the Effect was so surprisingly different that one would scarce think it should proceed from the same sort of body; for the Figure of my Hand and Fingers appeared not only on the inside (though more faint and pale than in the Experiments of Sealing Wax and Pitch), but on its

outside there appeared a brisk, purple Light, so beautiful and agreeable to the Eye that it was very pleasant to behold. The Strength of this Light may be judged from hence: That the Lines of the Palm of my Hand, which, being near the touching Parts, were easily discoverable by it; and were a small Print placed at the distance, I Question not but it would be legible without any great Difficulty. And as this common Sulphur differed vastly in that Part of the Experiment already related from the former, so, likewise, in the latter, for when the Hoop of Threads came to be held over it (under the same Circumstances as in the other) they were directed towards it as vigorously as in any Experiment heretofore made. The parts lined and transparent performed much alike, and if there was any Difference, it seemed to incline to that part lined with Sulphur."

A careful examination of these curious experiments would seem to show clearly that Hawksbee regarded them all as belonging to a single class; viz., as produced by the actual motion of matter in the condition of effluvia. In none of the preceding quotations does the word "electrical" or "electricity" appear, save only in the one instance, where he refers to the electricity on all parts of the glass producing the same effect on the hoop of threads. He appears to have been surprised by the fact that the phenomena were attended, as he mentions, by matter in some condition actually striking against the finger when it was approached to the glass globe, giving it a push like a puff of wind. Here, clearly, the conception of effluvial matter and not of convection breeze is uppermost in his mind.

Hawksbee appears to have made extended investigations as to the effect of this stream of what he regarded as effluvial matter. The result of these investigations was that he clearly outlined the effects of electro-static lines of force as they are generally known to-day. At that early date Hawksbee clearly denied the possibility of action at a distance, and seems to have acquired very advanced ideas concerning the mechanism of electro-static induction, the effects of which he also observed in the case of luminous phenomena being produced in a vacuous glass globe at rest, during the rotation and friction of a neighboring vacuous globe. He expresses himself thus concerning these phenomena:—

"Not only a Communication but a Continuity of Matter which occasions the Motion of the Threads. The Progress of it seems to be in a straight and direct track; in which the Matter is brushed by the shortest Course from the Approached Body to the Threads that are shaken by it. And if the Threads are moved by the influence of any Matter emitted from the Glass, it appears to be impossible to explain how they should be so and at such distances, without a Continuity. So that the case seems to be thus: That the Effluvia pass along, as it were, in so many Physical Lines or Rays; and all the Parts that compose them adhere and joyn to one-another, in such manner, that when any of 'em are pushed, all in the same Line are Affected by the Impulse given to the others."

But what is especially of interest in the experiments with the rotated vacuous globes is found in the fact that the production of an electric charge on the outside of these globes, while their interiors were in what was evidently a fairly high vacuum, permitted an image of the hand to be clearly discerned through the transparent part, although the hand itself was covered by a substance opaque to light; i. e., pitch or sulphur. Of course, as we now know, the phenomena of the image of the hand might be regarded as a luminous electric image produced by induction through the mass of the dielectric, including the glass and the sulphur or pitch.

While the description of the phenomena is fairly clear as given, one might almost suppose that the phenomena concerning the transparency of bodies ordinarily opaque under the circumstances, was descriptive of a series of phenomena which showed either that Hawksbee had at this early date reached, or actually passed, the border lines of the phenomena of the X, or Roentgen, and other allied rays. One can almost imagine, when reading his description of the appearance of the hand with what he calls the lines and the dark spaces between the fingers, that he was describing a species of radiograph. While we admit that this may seem improbable, yet it might be worth while for some investigator who has some little time at his disposal to repeat Hawksbee's experiments under as nearly identical conditions as possible, and test, by means of photographic plates or in other ways, whether there are any peculiar rays of the X or allied types present. Such an experiment might readily be tried by coating the entire interior with pitch, and placing a photographic plate, preferably concave, a short distance from the rotating globe, but above, to the side, and below the same.

But while Hawksbee failed to thoroughly grasp the details of his remarkable experiments, he did not fail to appreciate their strangeness. He remarks with considerable surprise the curious fact of opaque bodies that are so readily rendered transparent. As he says, this experiment shows some strange things. "Bodies which are really opaque have hitherto been thought to continue always so. It was never so much as suspected that they could exchange that quality for the contrary one, and then come back from that contrary to their old state again."

His closing words in this connection are indeed prophetic:—"This property, I say, is as new as 'tis real and surprising, and the bare consideration of so unlikely and unexpected a thing, may be a ground of encouragement to hope that some other odd properties of bodies, by some lucky trial, may hereafter (as it has done) surprise us with the discovery of themselves."

Witness the fulfilment of this prophecy in the discovery of the Roentgen or X-rays, the Leonard rays, the Becquerel rays, the cathode and other rays and their modifications, together with what may be regarded as their mutual sequence—that is, the discovery of the so-called elements, polonium, radium, and actinium, with their astounding physical properties that have so ruthlessly overthrown the old and (up to this time) apparently fundamental ideas of energy and the essential nature of atoms and molecules.

Shopping by Telephone

THE largest private telephone exchange in the world is said to be installed in the department store of Marshall Field & Company, at Chicago. Over 300 telephones are used in the establishment. On every floor, and serving each separate department—the department being further subdivided into aisles—are located telephone instruments by which the shopper can communicate with the outside world at a moment's notice. The company operates its own exchange and has an extensive intercommunicating system. The apparatus is leased and the talking current furnished by the Chicago Telephone Company.

A very modern feature of this service is the provision by Marshall Field & Company of expert shoppers, who may be called upon, through the medium of the telephone, to execute purchases for out-of-town or local patrons who find it impossible to make the trip to the store.

An international industrial exhibition is to be held at Cape Town, South Africa, during November and December, 1904, and January, 1905.

Some French Electric Coal Handling Machinery

By A STAFF CORRESPONDENT

OF the electrically driven machinery for handling coal and coke used at the various plants of the Paris Gas Company, a number of illustrations are given on this and the following pages. Not the least interesting of the devices, though of modest character, is the apparatus shown in Fig. 7, designed for lifting the bags of coke to a proper height for easily being taken upon the backs of laborers. The bags are carried along on an inclined conveyor of the type shown in Figs. 1 and 2 to the large heaps which are completed by the aid of a monorailway several hundred yards in length. As they come from the conveyors the bags are placed on the carriers shown in Fig. 5, which are provided with wheels traveling on the monorails. These two-bag carriers are connected together, the loaded ones in descending causing the empty ones to be raised on the return track.

One of the most interesting labor-saving devices employed at these French plants is an electric bucket conveyor for raising the coke from the piles and carrying it into chutes, from which it passes into hectolitre measures and is then dumped into bags and loaded upon carts and wagons for distribution about the city, or for conveying to cars for transportation. This conveyor is illustrated in Figs. 3 and 4. The current is conveyed to the apparatus by overhead wires attached to a pole as shown and connected with the electric motor which operates the chain of buckets. This chain consists of 150 links and carries thirty buckets which dig into the pile of coke, conveying it over the top of the device into the hopper. The coke passes through three chutes to the measurers, each of which is controlled by a lever operated by the laborer who fills the sack and passes it back to be loaded upon the wagon.

Different methods are employed at the various works at Clichy, La Villette and Ivry, all of which are owned by the Compagnie Parisienne d'Eclairage & de Chauffrage par le Gaz. The various systems of coal and coke conveying utilized at these plants were installed to meet the special conditions required at these works for the most economical as well as the most expeditious handling of the materials.

The portable conveyor for filling the bags with coke from the pile is supplied with power from an electric motor located under the platform of the truck. The measuring and bag-filling mechanism has an output of about 1,500 cubic feet per hour. The buckets attached to the two chains are continually pressed against the coke pile, and after the coke is discharged into the hopper, the fine dust is sifted out in the three chutes as it passes into the measuring devices. At some of the plants the coke passes through chutes directly into the measuring and loading apparatus. This apparatus allows the bags to be filled without labor and with one hand, similar devices being employed under the chutes of the coke crushers. The bags are hooked to the hoppers into which the measures dump the coke and the opening and closing of the chutes is accomplished automatically by the measuring device itself as it arrives at or leaves the filling position.

After the bags are filled they are lifted mechanically, as already mentioned, to a proper height so as to be easily taken upon a laborer's back. There are two or more shelves on these lifting devices, located near the crushers and storage rooms. These shelves have a continual motion up and down, stopping an instant at the top and the bottom, the bags being placed on the shelves when they are at the ground level and taken from the shelves by the laborers when they reach a height of four or five feet,—near the top.

At some of the plants it is found desirable to dry the coke, which is accomplished by means of a drying conveyor. This drying apparatus has a large capacity and travels in a heat-

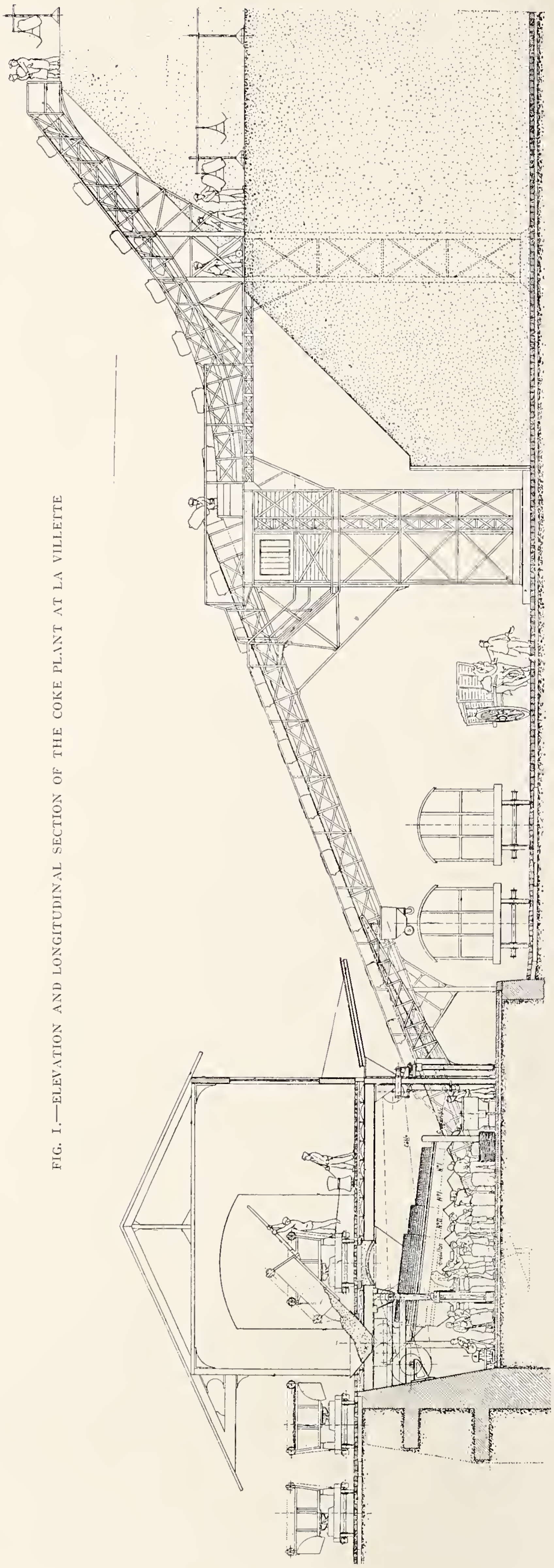


FIG. 1.—ELEVATION AND LONGITUDINAL SECTION OF THE COKE PLANT AT LA VILLETTE

FIG. 2.—A COKE BAG CONVEYOR AT THE LA VILLETTE WORKS

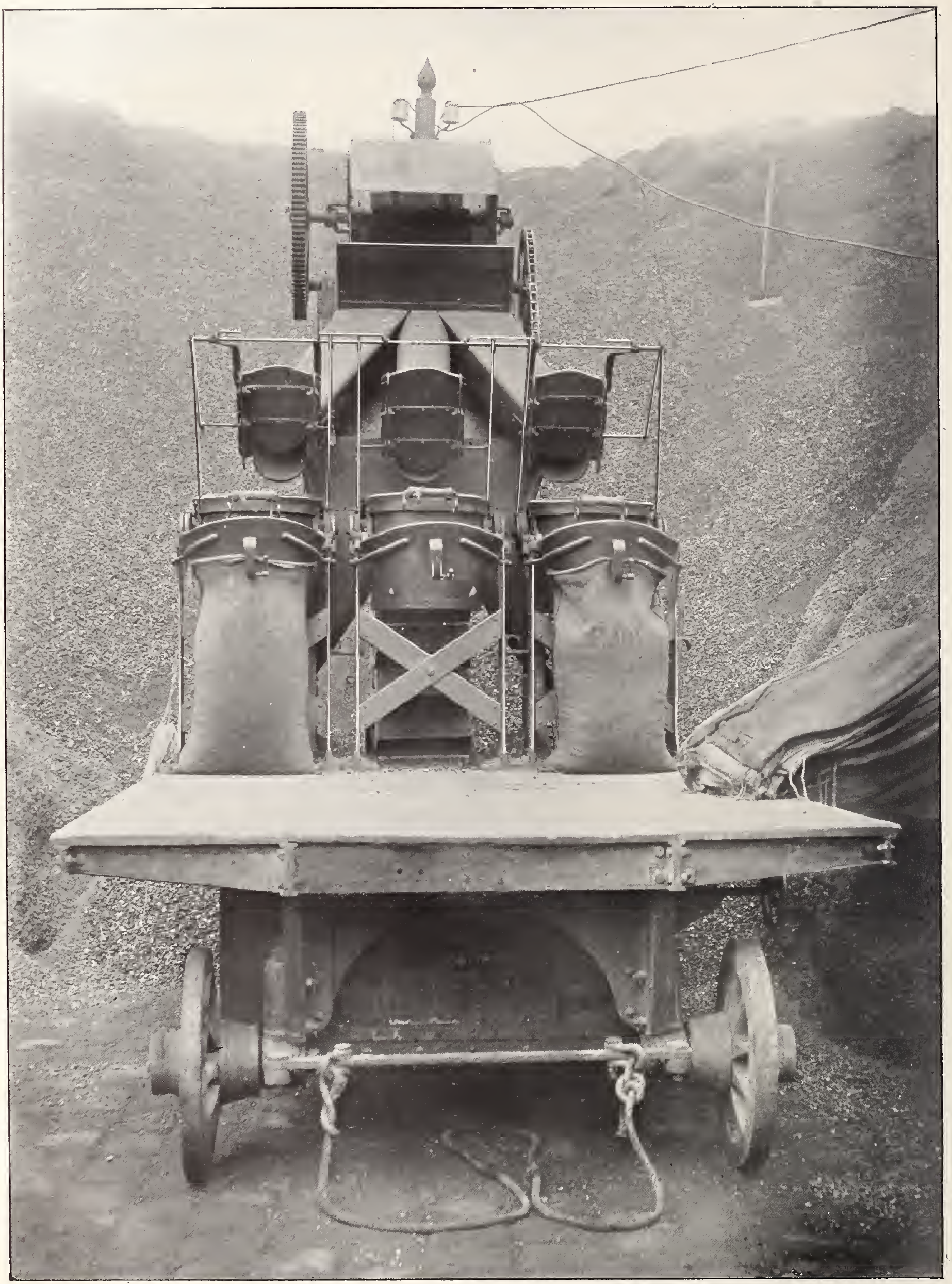
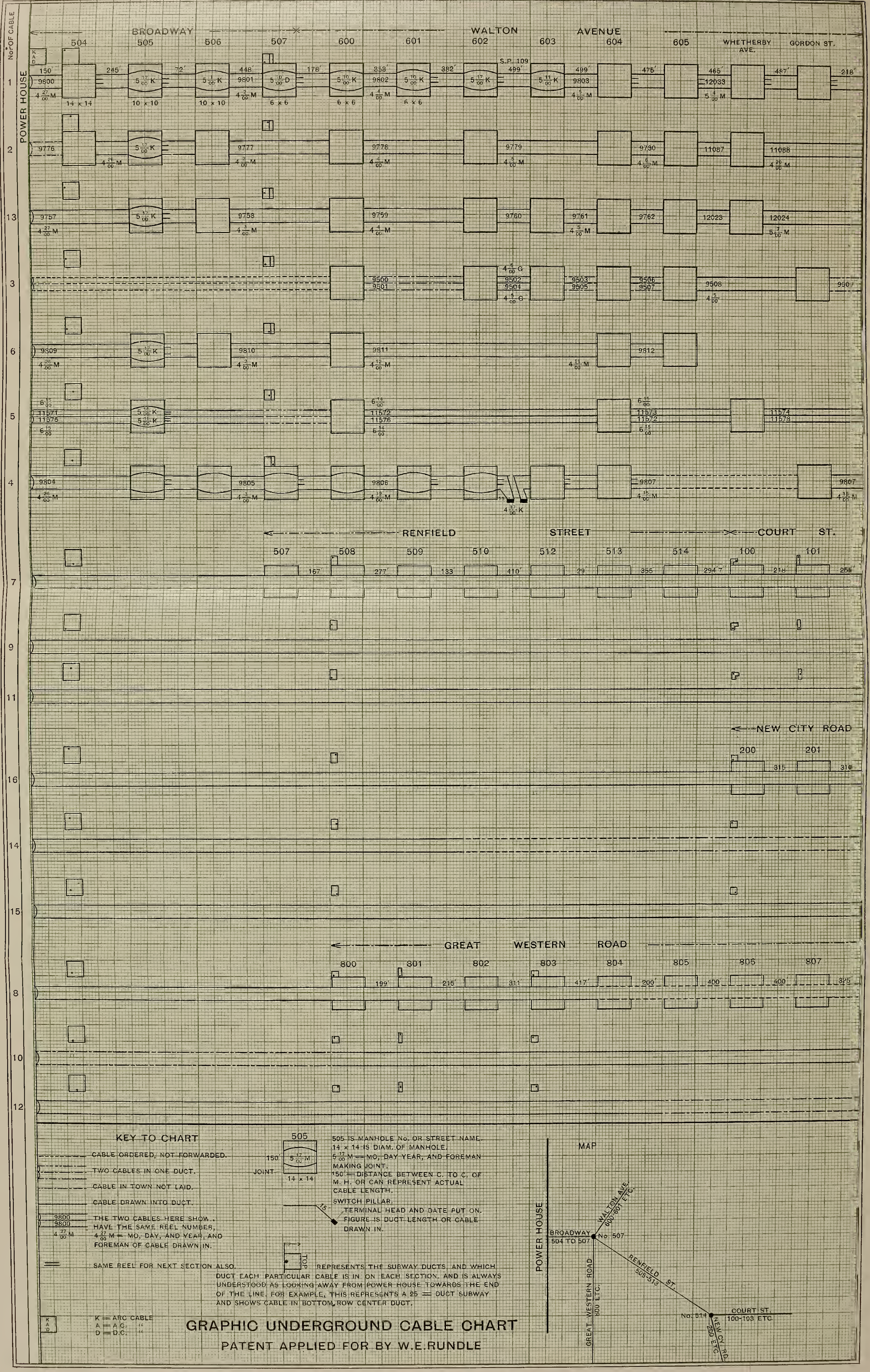


FIG. 3.—ELECTRIC BUCKET CONVEYOR FOR LOADING COKE SACKS

FIG. 4.—ANOTHER VIEW OF THE CONVEYOR SHOWN IN FIG. 3

FIG. 5.—TWO-SACK MONORAIL CARRIERS

FIG. 6.—SINGLE-SACK COKE CARRIERS ON AN AERIAL CABLEWAY AT IVRY



SUPPLEMENT TO "THE ELECTRICAL AGE," APRIL, 1904. COPYRIGHT, 1903, BY LOUIS CASSIER

ed inclosure at a speed of 8 feet per minute from a point near the crushers to the place where the cars are loaded. The conveyor is about six feet wide and the wet coke as it comes from the crushers is carried by means of buckets to the drying floor, where it is heated for about half an hour as it passes along, and finally, after passing through a chute, is emptied into the cars by a bucket lift.

Sack conveyors are employed for piling the coke at the works where these great heaps are required for storage. These conveyors carry the coke bags to a height of from fifty to seventy-five feet, the bags being placed upon supports carried by a moving chain on a framework, the speed of the chain being from sixty to seventy-five feet per minute. This conveying apparatus handles about fifteen bags per minute or a total of nearly 10,000 bags per day of ten hours. The conveying chain for piling the coal at La Villette starts at the crusher shed and passes up an inclined framework from the lower platform ending above the coke pile. At this point a horizontal conveyor is also employed, the bags passing under the crushers to the elevator for placing on the piles. At the works at Clichy a carrier lift is provided and also a horizontal conveyor which ends in an incline conveyor for raising the coke bags to the car level, a continuous drying conveyor further being used in connection with this plant, the coke being heated on its way to the cars for a period of thirty minutes or more.

A monorailway is employed at Clichy for completing the piling after the bags have been delivered upon the heaps by the inclined conveyors. These monorailways are 1,000 feet or more in length and are constructed as desired on the tops of the great piles of coke. A large number of straight and curved rails are provided which are supported by light arched standards. These may be easily moved by the laborers, the monorail being lengthened wherever desired for dumping additional coke. The inclination of the monorails is less than 1 inch to 100 feet and the carriers each handle two bags having a capacity of about three cubic feet and weighing somewhat over 100 pounds.

At the works at Ivry cable ways are employed, a single bag being handled by each carrier. This method is employed for piling the coke, while similar conveyors to those above described are employed for loading the bags to wagons or cars. The endless cable used on the telpherage conveying system at Ivry supports the single bag carriers, and the carriers are switched automatically by the cable to an angle-iron railway. By this telpherage system about 2,000 bags are handled per day of ten hours with ease.

These plants were installed under the direction of Mr. L. Bertrand, "Directeur de la Compagnie Parisienne." Several hundred thousand tons of coal are used at these works each year, and about fifty million cubic feet represent the output of coke. The plants cost about a quarter of a million dollars and occupy an area of several million square feet.

Whether the coal is brought to the works by barges or by trains of cars, it is unloaded by cranes and conveyed at the lowest possible expense to the furnaces where it is distilled and then carried to the coke yards. The dump carts which carry the coke to the crushers work automatically, and electric-motor-driven capstans are employed in the dumping of the cars at La Villette.

While the methods employed by the engineers of the Compagnie Parisienne may not be favored by American engineers, they are interesting as illustrations of French practice, differing materially from systems for conveying coke and coal at similar establishments in the United States.

FIG. 7.—LIFTING THE SACKS BY MACHINERY TO THE BACKS OF LABORERS

The painter Michetti, who designed the new Italian postage stamps, has devised an ingenious detail for the two-centesimi stamps, which are in honor of Marconi—a telegraph pole from which the wires hang down useless. All the stamps were made at the desire of the King, who had come to the conclusion that Italy's stamps were no better than those of France, England and Germany, and did not reflect honor on a country known as the home of classical art.

The Chamonix Electric Railway

Water-Power and Protected Third-Rail Current Supply

By ARCHIBALD WILSON

PREVIOUS to 1902 the tourist, en route for Chamonix from the direction of Geneva, had, of necessity, to perform the last stage of the journey by diligence. Cluses was then the terminus of the Paris-Lyons-Mediterranean Company's steam line, and from there a drive of twenty-seven miles through the wild valley of the Arve brought the traveler to his destination. Lying, as it does, under the shadow of the great Mont Blanc range, Chamonix has a world-wide reputation as the centre of some of the loveliest of mountain scenery and as a convenient starting point for numerous Alpine ascents, and its ever-increasing popularity made its connection with the railway system of France merely a question of time.

By July, 1901, the ordinary steam railway had been extended a further distance of seventeen miles to the small town of Le Fayet, and from that point to Chamonix the electric railway which is the subject of this article was opened for traffic. The line is a comparatively short one, being at present slightly under twelve miles in length from terminus to terminus, and is provided with four intermediate stations. Of these Chedde is next to Le Fayet-St. Gervais, then come Servoz, Les Houches, and finally, about two and one-quarter miles from Chamonix, the station of Les Bossons, situated at the foot of the famous glacier of the same name. As the difference in level between Le Fayet and Chamonix is about 1500 feet, the gradients are in some parts steep. The heaviest are, one of 9 per cent. between Chedde and Servoz, extending over a distance of 2300 yards, and one of 8 per cent. between Servoz and Les Houches, 1500 yards in length, while inclines of 2 per cent. are frequent.

For the first two miles the line runs through a comparatively level and open valley to Chedde, shortly beyond which the heavy climb begins. Beyond Servoz the valley of the Arve, which there narrows into a wild and precipitous gorge, affords ample scope for the ingenuity of the engineer in the necessity for deep rock cuttings, tunnels, and high embankments. Incidentally, it may here be mentioned that at a short distance from Servoz station there may be seen at the entrance of a rock gallery through which the high road has been driven, an interesting example of tunnelling by the Romans. The mouth of the tunnel is approached by steps cut in the rock at the side of the road, and is furnished with a signboard which informs the traveler that the ancient tunnel was discovered while blasting out the rock of the modern tunnel for the construction of the high road about the middle of the last century.

At the head of the gorge the line crosses the Arve by a lofty masonry bridge, after which it ascends by easy

THE POWER STATION NEAR SERVOZ. A SECOND STATION AT CHAVANT, ABOUT THREE MILES DISTANT, IS SIMILAR IN LAY-OUT AND CAPACITY

gradients along the more open Chamonix valley through the stations of Les Houches and Les Bossons to its terminus.

From a picturesque point of view the railway can hardly be surpassed, the sight of the turbulent glacier waters of the Arve rushing through its gorge as the train winds its way high above the stream being varied by exquisite glimpses of snow-clad mountains and the rocky pinnacles of the Aiguilles, till finally, as the train emerges into the valley of Chamonix, there bursts into view the entire range of Mont Blanc with its snowy summits and glacier-covered sides.

As a natural sequence to the line being projected through a country lavishly provided with streams of rapid descent, water-power has been employed as the source of energy for the propulsion of the trains. Two power stations have been erected, one a short distance below Servoz, about four and one-half miles from the LeFayet end, and the other at Chavants, two and three-quarter miles further up the valley. The general appearance of No. 1 Station at Servoz can be gathered from the illustration on the opposite page. The power house measures 100 feet by 40 feet, and consists of a basement through which are brought the inlet and discharge pipes of the turbines, and a first floor containing the turbines, dynamos, and switchboards.

The water is led from the river through tunnels and riveted steel pipes according to circumstances, and is delivered to the turbines at a pressure corresponding to a head of 130 feet. The machinery consists of four main turbines with horizontal shafts direct connected to the generators which supply current to the line, and two smaller turbines and dynamos which are used for the lighting of the station and its adjuncts. The large turbines have a maximum capacity of 350 horse-power.

The dynamos at No. 1 Station give out 550 volts at their terminals at no load with a speed of 615 revolutions per minute. With a speed of about 450 revolutions and a load of 440 amperes the pressure is 522 volts. The normal output of each generator is 370 amperes for continuous running; 450 amperes may be taken off for half an hour at a time; and for momentary periods of overload the current may run as high as 600 amperes, at which figure the automatic cutouts at the switchboard act. The exciter sets are designed to work at 120 volts with a maximum of 330 amperes, and their turbines are provided with governors maintaining the speed constant with all loads at about 520 revolutions per minute. No. 2 Station at Chavants, while differing slightly in detail, is equipped generally on lines similar to the station at Servoz. The head of water in this case is about 300 feet.

SEEN FROM THE TRAIN

THE FRONT LUGGAGE VAN, WITH THE DRIVER'S COMPARTMENT

Current is conveyed to the motors of the trains by means of a third contact rail laid outside and parallel to the ordinary running rails. This third rail, which weighs slightly under 75 pounds per yard, is placed on one side or the other of the line according to necessity, at a distance of about 42 inches from the centre of the line and with its

THE WAY IN WHICH THE CONDUCTOR RAIL IS GUARDED AGAINST ACCIDENTAL CONTACT IS HERE CLEARLY SHOWN

crown 9 inches above the top of the running rails. It is fixed with iron bolts to insulating blocks of paraffined beech, which, in turn, are bolted to oak distance pieces fixed on the ends of the sleepers. It might naturally be suggested that such support did not possess sufficiently high insulating qualities having regard to the pressure employed, and that the leakage from the line would be considerable. Apparently, however, this is not the case, for the maximum leakage to earth is stated at less than one ampere per 1000 yards.

Moreover, it is also asserted that this leakage decreases with a fall of rain or snow. The reason given for this somewhat unusual state of matters is that dust, which has accumulated on the surface of the insulating blocks and caused leakage, is washed away by the action of the rain, while the water itself in the Chamonix district is so pure and free from acids or alkalies that its conductivity is practically nil. In consequence, after rain the insulation of the wood blocks is, on the whole, greater than before.

THE ARRANGEMENT OF THE CONDUCTOR RAILS AT A SWITCH

In addition to having fish-plates of standard pattern, the adjoining ends of the third rails are connected by two stranded copper bonds soldered to cast iron terminal plates which are bolted to the web of the rail. The running rails are bonded in similar fashion, but with only a single bond per joint.

To allow of the passage of vehicles at grade crossings, and also at switches, a gap is left in the contact rail, the interval being bridged by a copper bond laid underground in a wooden trough run up solid with asphalt. At all such interruptions the rails are so disposed that at no time are the collector shoes on the vehicles entirely out of contact with the rail, and no interruption of the current to the motors, therefore, takes place. In the stations and other such places where the public may have access to the line, the contact rail is protected by a guard plank in such a way as to prevent accidental contact and still allow of the passage of the shoes. Elsewhere the rail is without protection of any sort. The disposition of the rail guard is very well shown in the illustrations on this page.

All the vehicles at present in service

on the railway are equipped with motors and comprise eight different types, namely, front baggage vans, first-class carriages, second-class carriages, combined first and second-class carriages, and three types of goods wagons.

Each motor truck has two axles with 36-inch wheels, and each axle is driven independently by an electric motor. The motors are designed to run at a speed of 275 revolutions per minute, and are individually capable of working at the rate of 65 horse-power during a continuous run of two hours without excessive rise of temperature, while for short periods double this power can be obtained from them.

Owing to the narrow gauge of the line—one metre—the space inside the truck frame is somewhat restricted, and in consequence the motor shaft is placed at right angles to the axles, necessitating the use of bevel gearing. The gear wheels are of steel with machine-cut teeth, and work in a bath of oil. The larger of the two gears is mounted on the axle, to which it is attached by a flexible spring coupling provided for the purpose of lessening vibration and the effect of sudden strains on the armature. The motor frame is pivoted at the driving end on two arms which embrace the axle, while the other end is supported on springs attached to the truck frame. In this way, while the motor has a flexible support and is free to move to a limited extent, the exact relative positions of the gear wheels to one another are always maintained.

To make contact with the third rail, each truck is provided with four collector shoes, two being fitted on each side. The shoes are supported on a system of hinged joints, and are pressed downwards by springs so that they follow any inequality in the height of the rail and always make good contact with it. The brackets to which the shoes are attached are bolted to the extreme ends of the truck frame, but are, of course, insulated from the frame.

For starting, stopping, reversing and varying the speed, each vehicle is provided with a controller, the handle of which can occupy any one of eleven different positions. Of these, the centre one is "off" position, five are used for going forward, and the other five for reversing. Of the five working positions, three are employed in starting, the fourth for running at normal speed, and on the fifth a higher speed can be obtained by reducing the excitation of the motor fields.

Each vehicle can be controlled independently by hand by means of a removable crank applied to the controller, but such a method is rarely employed except in shunting operations. When, as is usually the case, a train of from four to six vehicles is being run, the controllers in all the vehicles are worked simultaneously by compressed air motors whose action is regulated solely from a driving cab fitted in the front of the luggage van at the head of the train. For this purpose an air motor is fitted on the truck frame beneath each electric controller. These air motors are coupled to, and set in motion by, a master air controller fitted in the cab, so that to place the electric controllers on each vehicle in any desired position the driver has simply to move a hand wheel to the right or left, when each air motor moves its controller over to a corresponding degree. Accordingly, the control of a train is as easily and quickly effected as that of a single vehicle.

Power for working the compressed air controlling gear and also for the brakes is derived from a motor-driven air compressor in the luggage compartment behind the driver. In addition to the master controller, there is fitted in the cab various other apparatus required for working the train, including a connection box and automatic cutout for the motors, the latter set to open the circuit at 400 amperes, an ammeter, a speed indicator, switch gear for the compressor motor and for the lighting and heating circuits of the train, hand and air brake levers, and a whistle, also worked by compressed air. On the roof are fitted air reservoirs, while beneath the floor of the cab, and also of the various other vehicles, are suspended the air motors and the several starting resistances.

The brakes, as has been mentioned, may be worked by hand or by compressed air, and are of two types. For ordinary service, each wheel is provided with a shoe brake acting on the rim in the customary manner. For additional safety a double-jaw brake is provided which grips the sides of a rail fixed in the centre of the permanent way slightly above the level of the running rails. This brake-rail is laid down only on the heavy grades. Under ordinary conditions the wheel brakes only are used, the jaw brakes being reserved for emergencies or in case of prolonged stoppage. In the illustration of the power station on page 242 the brake-rail can be seen in the centre of the line.

The seats of the carriages are disposed at right angles to the length, with a passage down the middle. The lighting is by means of incandescent electric lamps and the heating by electric radiators underneath the seats. Sitting accommodation is provided for twenty-four first-class passengers in each carriage, while the second-class carriages have seats for twenty-eight persons. In addition, at each end of the carriages of both classes a covered platform affords standing room for four persons. The windows are excellently arranged, providing ample ventilation and an uninterrupted view of the scenery. Each passenger carriage weighs about 19 tons when empty.

ONE OF THE FIRST-CLASS CARRIAGES. AN ELECTRIC CONTACT SHOE CAN BE SEEN AT THE RIGHT OF THE CONDUCTOR RAIL SECTION

The goods wagons have a platform at one end only, on which are mounted the controller, an automatic cutout and the hand-brake levers. In other respects their construction is not very different from that of the goods wagons of an ordinary steam railway. The weight of a goods wagon when empty ranges from 18 to 20 tons, according to the type, while the carrying capacity

A VIEW ALONG THE PIPE LINE. SOME OF THE OVERHEAD FEED WIRES CAN HERE ALSO BE SEEN

of all three types is about 10 tons. The tare of the wagons is thus high in proportion to the load carried; but this is due to the fact that each wagon has its own motors, and is in consequence an independent unit, capable, if need be, of making a journey unassisted and of performing its own shunting.

The speed which the trains attain on the level is at the rate of about 25 miles an hour; when ascending a 2 per cent. incline, $15\frac{1}{2}$ miles; and on the heaviest inclines of 8 and 9 per cent., 8 miles.

The International Electrical Congress at St. Louis

THE following papers have been promised for Section A—the section on "Theory," of the International Electrical Congress, to be held at St. Louis this summer, Prof. E. L. Nichols being chairman, and Prof. H. T. Barnes, secretary:—

Prof. Dr. Paul Drude, "Metallic Conduction."

Prof. Dr. W. Jaeger, "Electrical Standards."

Sir Oliver Lodge, F. R. S., "Ions."

Prof. H. Nagaoka, "Magneto-Striction."

Prof. J. J. Thomson, F. R. S. (subject to be announced).

Prof. J. S. Townsend, F. R. S., "The Theory of Ionization by Collision."

Mons. J. Violle, "Secondary Standards of Light."

C. T. R. Wilson, F. R. S., "Condensation Neuclei."

Prof. P. Zeemann, "Magneto-Optics."

Prof. H. T. Barnes, "The Mechanical Equivalent of Heat as Measured by Electrical Means."

Dr. Carl Barus, "Atmospheric Neuclei."

Dr. Louis A. Bauer, "The State of Our Knowledge Regarding the Earth's Magnetism."

Prof. D. B. Brace, "Magneto-Optics."

Prof. H. S. Carhart and G. W. Patterson, Jr., Ph.D., "The Absolute Value of the Electromotive Force of the Clark and Weston Cells."

Prof. C. D. Child, "The Electric Arc."

Dr. K. E. Guthe, "Coherer Action."

Prof. E. P. Lewis, "Electrical Discharges in Gases."

Prof. L. T. More, "Electrostriction."

Prof. E. F. Nichols, "The Unobtained Wave-Lengths Between the Longest Thermal and the Shortest Electric Waves yet Measured."

Prof. E. L. Nichols, "Standards of Light."

Harold Pender, Ph.D., "Magnetic Effect of Moving Charges."

Dr. M. I. Pupin, "Electrical Theory."

Dr. Edward B. Rosa, "Alternating Current Measurements."

Prof. E. Rutherford, "Radioactive Change."

Prof. J. C. McLennan, "Radioactivity of the Atmosphere."

Prof. J. Trowbridge, "Electrical Discharge in Gases."

Prof. A. G. Webster, "Electrical Theory."

It is evident from the above list that an excellent programme has been secured. Acceptances of membership in the congress are over 1300 up to the present time, and 150 papers have been promised in all. The following societies have all promised to hold conventions at St. Louis, during the congress week, and to hold conventions with one of more sections of the congress:—

The American Institute of Electrical Engineers.

The American Physical Society.

The American Electro-Chemical Society.

The American Electro-Therapeutic Association.

The International Association of Municipal Electricians.

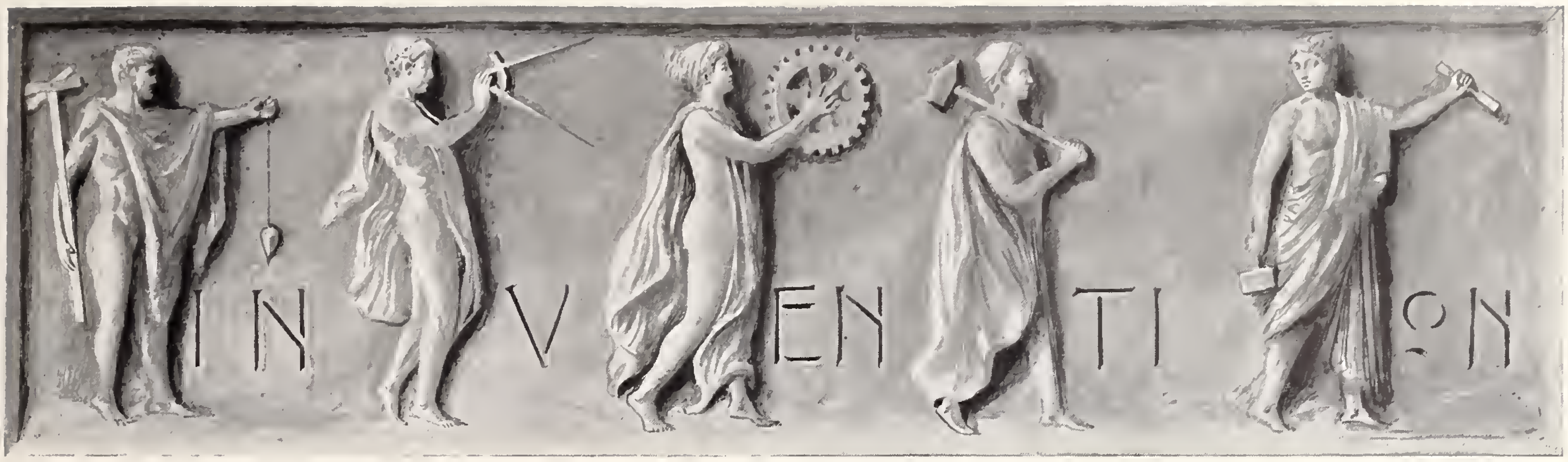
The British Institution of Electrical Engineers has also arranged to cooperate under some plan, the details of which have not yet been determined.

The following bodies have promised to co-operate by sending delegates:—

The Société Internationale des Électriciens.

The National Electric Light Association.

The Association of Edison Illuminating Companies.

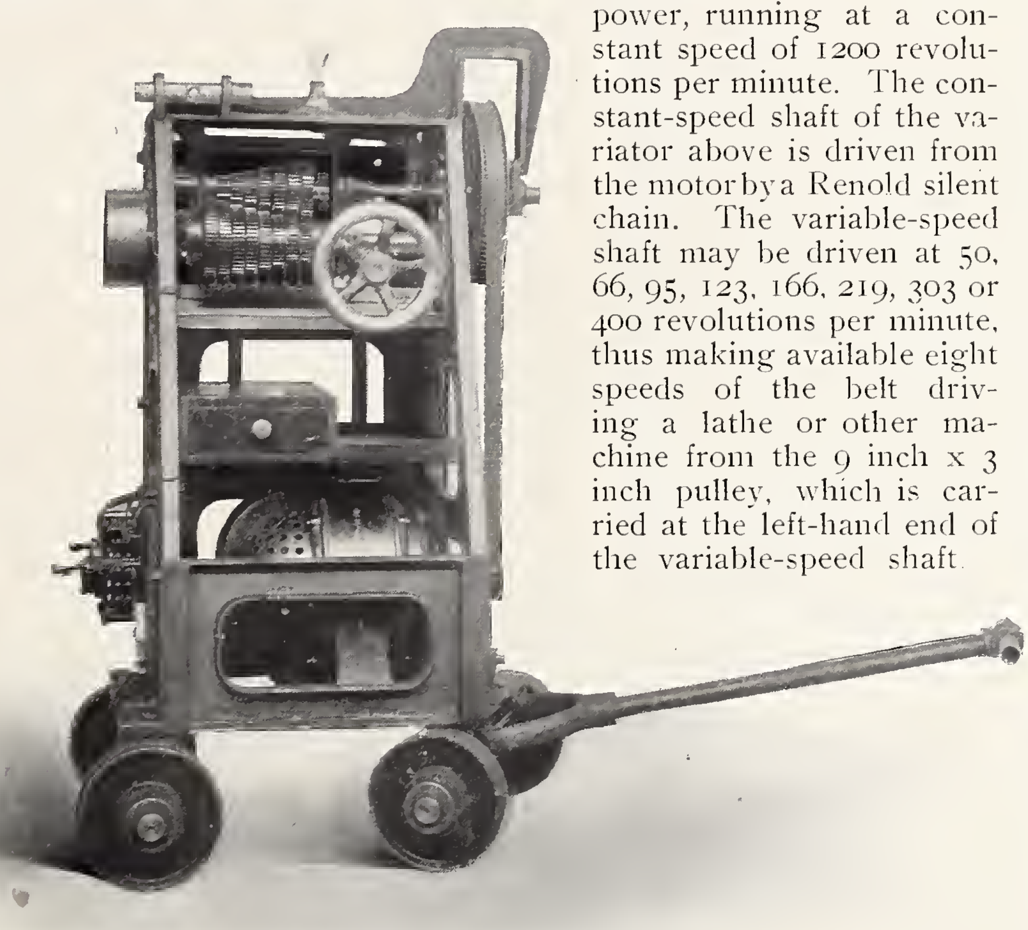


Electrical and Mechanical Progress

A Portable Variable-Speed Motor-Drive

IT is often a matter of delay and expense to remove a completed machine from the erecting floor or other place to the testing room where suitable provision is made for driving. To avoid this, the Lodge & Shipley Machine Tool Company, of Cincinnati, Ohio, have put into service in their tool testing room a portable drive of the kind shown in the accompanying cut. The outfit is intended not only for driving lathes in testing, but also for various other uses.

The drive, a simple combination of an electric motor with a variable-speed device, is carried within suitably arranged housings mounted on truck wheels. The motor is of $3\frac{1}{2}$ horsepower, running at a constant speed of 1200 revolutions per minute. The constant-speed shaft of the variator above is driven from the motor by a Renold silent chain. The variable-speed shaft may be driven at 50, 66, 95, 123, 166, 219, 303 or 400 revolutions per minute, thus making available eight speeds of the belt driving a lathe or other machine from the 9 inch x 3 inch pulley, which is carried at the left-hand end of the variable-speed shaft.



A VARIABLE-SPEED MOTOR-DRIVE. MADE BY THE LODGE & SHIPLEY MACHINE TOOL COMPANY, CINCINNATI

The height of the driving pulley is such as to afford good lead of the belt to the machine under test. A small, double-flanged pulley, hung from a swinging arm, serves as a tightener in adjusting the belt tension, and reduces the time and care which would otherwise be necessary in setting the drive to suit a belt of given length.

Electrically Driven Worthington Turbine Pumps

OF the several types of centrifugal pump now put on the market by H. R. Worthington, Inc., of New York, special interest is attached to their so-called turbine pump, illustrated on the following pages, and intended for very high lifts, up to and even exceeding 2000 feet.

In this pump the impeller is similar to that of the ordinary centrifugal pump, but after leaving it, the water is received by a system of diffusion vanes similar in construction but the opposite in function to the guide blades of a pressure turbine water wheel. The water delivered at high velocity from the impeller enters the passages between these blades through openings having a small cross section. The area of the cross section of the channel gradually enlarges, so that by the time the water reaches the discharge chamber it has been brought almost to rest without shock or friction, converting its energy of motion into energy of static head in a very efficient manner.

One of the difficulties presented by high-lift centrifugal pumps has been the great peripheral speed required when only a single impeller is employed. This has been overcome in the Worthington multi-stage turbine pump by mounting a number of discs or impellers, each operating in a separate chamber, upon a single shaft and passing the water through the impeller chambers in succession. The lift can thus be multiplied three, four or

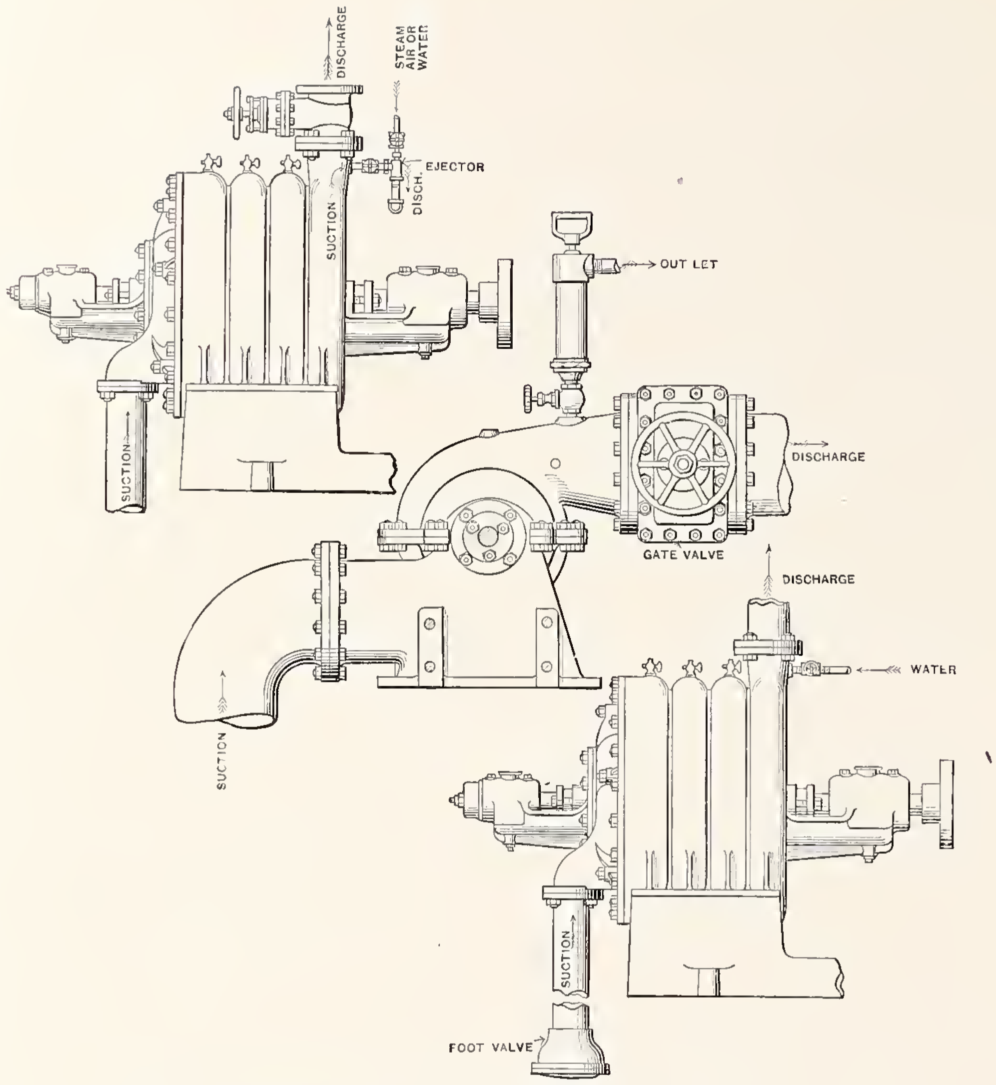


FIG. I.—DIFFERENT WAYS OF STARTING A CENTRIFUGAL PUMP

five times, while the number of revolutions is kept within such bounds that it is possible to connect the pump directly to a steam engine or an electric motor.

Figs. 2 and 3 represent horizontal shaft pumps, while Fig. 4 shows a vertical shaft design. It is frequently found necessary to locate a centrifugal pump in a pit below the floor level, in order to get within suction distance of the water supply. In cases of this kind the vertical centrifugal has been extensively used and has proved very satisfactory. The pumps can be either belted or connected directly to vertical motors. The latter method makes an ideal pumping plant, as the motor can be located above ground where it is free from all moisture and can receive proper care. The design of the pump is such that it requires very little attention, and it is necessary for the attendant to go down into the pit only at long intervals. A number of these pumps are being used at blast furnaces and steel mills for general water service. They are also widely used in irrigation for pumping from wells in which the water level fluctuates greatly, often submerging the pump and rendering the use of horizontal belted or motor-driven pumps inadmissible.

The electric motor enters a widened field of usefulness through the improvement of the centrifugal pump, as the two are perfectly adaptable to each other. A motor-driven pump set is very similar in operation to a motor-generator set, the output being water under pressure in the first case, instead of electric current. At constant speed the power and output are inversely proportional to the resistance to flow, and the efficiency is practically constant within wide limits.

The operation of the pumps by electric motors is often a complicated problem. First of all, there are very few places where a constant delivery of water is wanted. To vary the quantity, then, it is necessary either to vary the speed of the motor or to provide a complicated and unsatisfactory system of by-pass valves, both of which methods are in general wasteful of power and unsatisfactory in operation. In some cases automatic devices are installed, intended to stop and start the motor whenever the pressure falls short of or exceeds certain limits. In the centrifugal pump, on the other hand, the flow is automatically regulated by the pressure and the pump may be so designed that this regulation will be very close and exact.

The centrifugal pump is noiseless and the speed can be made to fit the requirements of the motor. There is no shock or pulsation in the piping and nothing disastrous happens if the discharge is stopped. In the case of alternating-current motors the centrifugal pump has a decided advantage in that the starting torque is very low, especially if the discharge valve is closed.

Fig. 1 illustrates several methods of starting centrifugal pumps. Before starting, the pump casing and suction line must be filled with the fluid to be pumped, as machines of this type will not create a vacuum of any moment without first being primed. Numerous devices are employed for this purpose, but the methods here illustrated are those most generally used.

The upper diagram shows a multistage turbine pump with an ejector for priming. The ejector is connected to the highest point on the pump casing, and either steam, air or water under pressure may be employed to produce a vacuum.

The middle diagram shows an auxiliary hand pump mounted on top of the discharge casing. When the pump is ready to start, the gate valve auxiliary hand pump mounted on top erating the hand pump a vacuum is

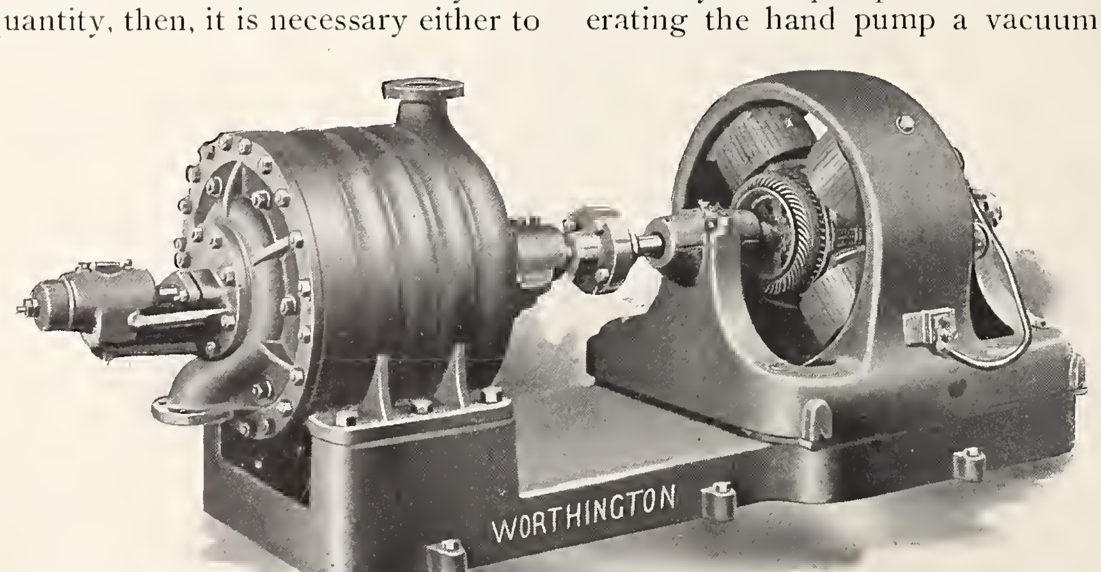


FIG. 2.—A FIVE-STAGE WORTHINGTON TURBINE PUMP. THIS ILLUSTRATION CONVEYS AN EXCELLENT GENERAL IDEA OF THE WORTHINGTON MULTI-STAGE TURBINE PUMP AS CONSTRUCTED FOR DEEP MINE AND OTHER SERVICES WHERE HEAVY PRESSURES ARE ENCOUNTERED. THE FIVE-STAGE PUMP IS ADAPTED TO ANY CAPACITY AND FOR HEADS UP TO 750 FEET

produced and the water is drawn in, filling the suction pipe and casing.

The method of priming shown in the bottom diagram may be resorted to where a foot valve is used on the suction pipe. Water is allowed to run into the pump until it reaches the discharge flange, when the supply is shut off, and the pump may be started. After the pump has been properly primed, it should be started before the gate valve on the discharge is opened. When full speed is reached, the discharge gate may be slowly opened, and the pump will perform its work in a proper manner.

Steam Turbine Power Plant for Boston Navy Yard

An interesting departure in engineering practice by the authorities of the United States Navy, Department of Yards and Docks, is marked by the introduction of Westinghouse-Parsons steam turbines for furnishing power for lighting the buildings and yards, and power for operating dry dock pumps and miscellaneous machinery.

The initial installation of this character is in progress of construction at the Charlestown Navy Yard, Boston, Mass., and for the present one Westinghouse-Parsons turbine generating unit of 750 K. W. capacity will be there placed in service. This turbine will be of the new short-barreled type, and is now under construction at Pittsburgh. A Worthington surface condenser will be employed, using salt water for circulation. The condensers will be located between the foundations, which consist of concrete piers. A running vacuum of 28 inches will be secured by a dry air pump. Steam will be furnished at 150 pounds pressure by Babcock & Wilcox boilers in units of 350 H. P., equipped with Roney mechanical stokers. Coil superheaters in the boiler settings will furnish to the turbine steam superheated about 100 degrees Fahr. The boiler house will be equipped with a complete outfit of coal and ash handling machinery.

The present power plant is the outcome of an appropriation made in 1898 by Congress for a dry dock and pumping plant to be located at the Charlestown Navy Yard. The new plans for a dry dock equipment provide for a power plant located near the outer end of the new dock with piping connections to both old and new docks, so that the one pumping plant would be able to handle them simultaneously or separately. During the period of construction of the new dock, the Department of Yards and Docks at this Navy Yard underwent considerable enlargement, necessitating an immediate increase in an electrical generating equipment for supplying light and power to buildings and departments.

In view of this situation, it was decided to supersede the dock pumping

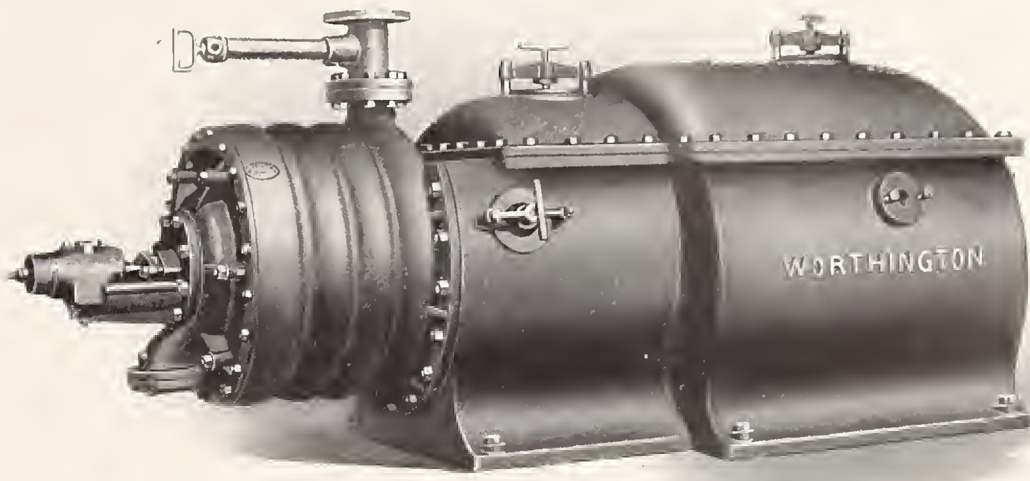


FIG. 3.—A FOUR-STAGE TURBINE PUMP WITH THE DRIVING MOTOR ENCLOSED IN A CAST-IRON HOUSING. THIS MACHINE WAS CONSTRUCTED FOR MINE SERVICE IN MEXICO, WHERE THE MINES ARE FREQUENTLY FLOODED, AND THE DESIGN PERMITS CONTINUOUS PUMPING EVEN THOUGH THE MOTOR AND PUMP BE SUBMERGED TO A DEPTH OF SEVERAL HUNDRED FEET. CAPACITY, 200 GALLONS PER MINUTE AGAINST 500 FEET HEAD.

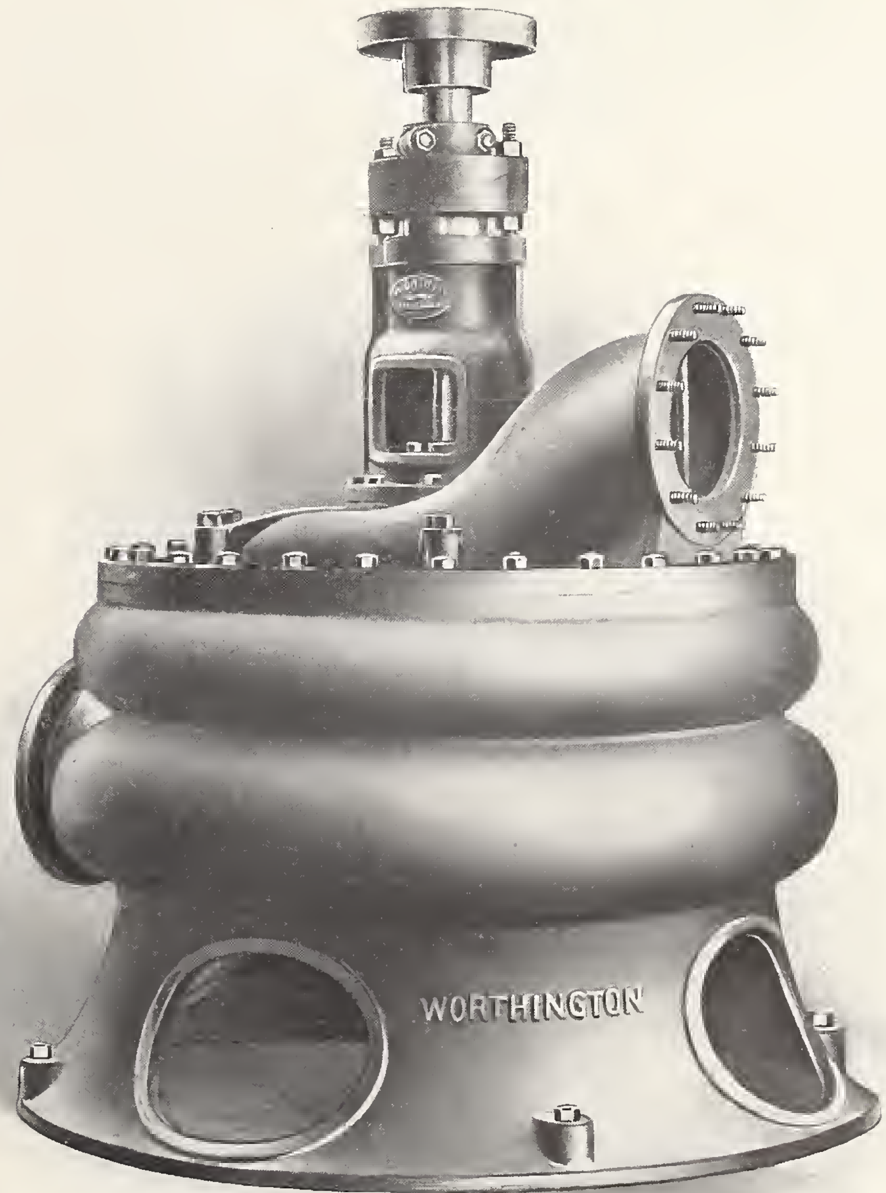
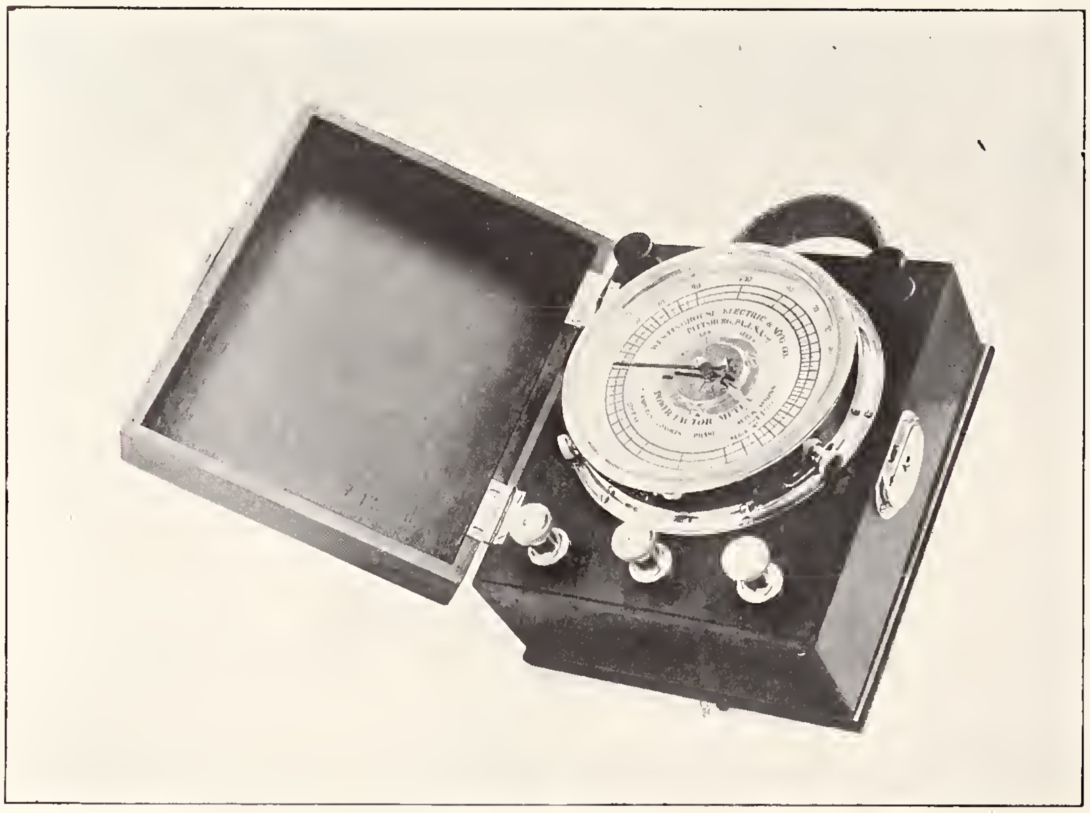


FIG. 4.—A TWELVE-INCH, TWO-STAGE, VERTICAL WORTHINGTON TURBINE, DESIGNED FOR DIRECT-CONNECTION TO A VERTICAL-SHAFT MOTOR. FOR GENERAL WATER SERVICE IN A LARGE STEEL PLANT. CAPACITY, 5,000,000 GALLONS PER DAY AGAINST 140 FEET HEAD

plant, originally provided for, by a central lighting, power and heating plant for the entire department, although retaining the dry dock equipment, which will now be electrically driven from the central station. It is also intended to supply from this plant electric light and power to the vessels docking which do not happen to be under steam. The power system as now under construction is, therefore, considerably more comprehensive than originally laid out.

The turbine plant will supply three-phase current at 2300 volts, this voltage being used for general distribution and for direct use in larger motors, while for lighting, lower voltage will be provided by transformation. The turbine generator will be served by a $37\frac{1}{2}$ K. W. Westinghouse compound exciter unit.

The engineering work is under joint execution by the Department of Yards and Docks and the constructing engineers, Westinghouse, Church, Kerr & Company, who are installing the plant.



A NEW PORTABLE POWER FACTOR METER MADE BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG

A New Portable Power Factor Meter

THE ordinary method of ascertaining the power factor of a polyphase circuit by means of a comparison of the indicated volt-amperes—a quantity obtained by the multiplication of the indicated voltage by the indicated ampere output—with the output in watts, is open to serious criticism. In addition to the tedium and inconvenience involved in making three observations, a multiplication and a division, there is an evident liability of error caused by the number of operations required to obtain the result, which is increased by the fact that readings are taken successively and not at the same instant. The inaccuracy of such a method is demonstrated by the fact that by its use there may be shown a power factor of over 100 per cent.—a physical impossibility.

It has been found possible to avoid errors and to simplify the process of determining the power factor of a polyphase circuit by employing a single instrument which indicates directly upon a scale the power factor of a circuit, reproducing on the dial, by the position of a pointer, the angle of phase difference, and giving the actual power in percentage of the apparent power. Such an instrument made in suitable form for testing purposes is shown in the accompanying illustration of the new portable power factor meter made by the Westinghouse Electric & Manufacturing Company. It operates with equal facility and accuracy on either a leading or lagging current, and indicates whether the current leads or lags, whether power is delivered to or by the circuit, and the power factor.

In principle, it consists of two sets of coils, one of which contains a separate series winding for each of the phases in the circuit, and the other a potential winding which is connected across one phase of the circuit. The series coils are so arranged as to produce a resultant rotating field. A small iron vane, passing through the potential winding, forms movable pole-pieces for this winding, which take up a position in the rotating field depending upon the phase relation of the currents producing this field and the voltage impressed upon the potential winding. The pointer, attached to the shaft carrying the movable vane, indicates on a scale the angle between the current and the voltage, the scale being so graduated as to read directly in power factor. Should the power factor of the different phases differ from each other, the instrument will indicate the average power factor.

Different instruments are provided for two and three-phase circuits. They are made with the same care and accuracy that is employed in the manufacture of the other Westinghouse testing instruments, are finely finished and provided with covers which are made removable for convenience in use.

A 1500 K. W. Alternator for St. Louis

THE National Electric Company, of Milwaukee, Wis., have installed at the Central Power Station at St. Louis one of their large alternators, direct-connected to a 2250 H. P. Hamilton Corliss vertical cross-compound engine. The rated output is 1500 K. W., 25 cycles, 6600 volts, running at 83 revolutions per minute. The power generated will be used for various purposes.

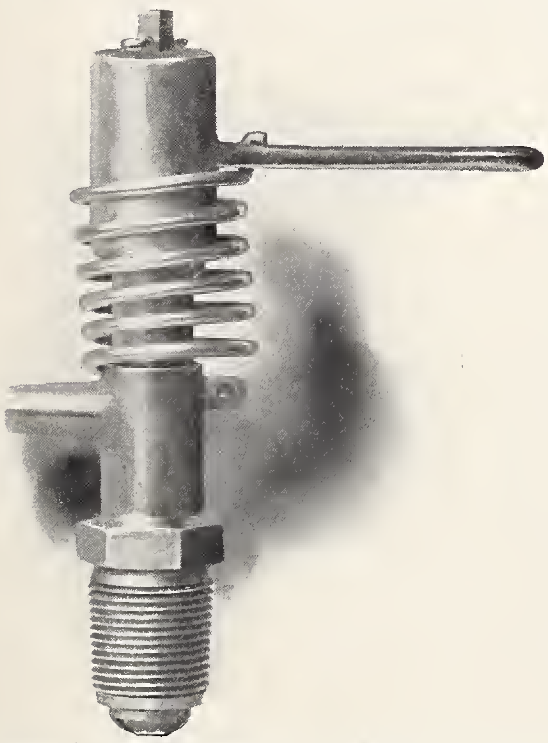
Like all standard alternators built by the National Electric Company, it is of the revolving field type, leaving the armature stationary and easily accessible, and the difficulty of properly insulating the armature coils is eliminated as the windings are not subject to any mechanical strains whatever. The revolving field is of large diameter, giving additional flywheel effect to the engine, and the construction of the field coils makes them practically indestructible. All parts are accessible, and the method of ventilation insures low temperatures.

The revolving field is made of cast-steel in halves, these being bolted and secured together by shrunk links. The rim of the wheel, to which the cast-steel pole pieces are bolted, is of channel cross-section. The field coils comprise sixty-five turns of $1\frac{1}{2}$ x $\frac{1}{8}$ inch copper strap, wound on edge and thoroughly insulated, the outer edge of the coil being exposed to the atmosphere for cooling. Laminated pole-shoes are secured to the ends of

the pole pieces and serve to hold the field coils in position. These shoes cover a large polar arc, distributing the magnetic flux evenly.

The frame is a circular cast-iron housing into which laminated punchings with inwardly projecting teeth are assembled, for the reception of the armature windings. The frame is extremely heavy and stiff, not requiring any external support, and is divided horizontally, the halves being firmly bolted and keyed together. Bolts and keys are contained entirely within the cross-section, obviating the use of side lugs. Large open spaces are provided in the sides of the frames, allowing a free passage of air from the ventilating ducts in the core.

The armature core is built up of laminated soft steel punchings, annealed and japanned before assembling, and ventilating space blocks are inserted at suitable intervals, providing openings extending around the circumference and allowing a free passage for the heat generated in the windings. There are six slots per pole, $2\frac{1}{2}$ inches deep x $1\frac{1}{2}$ inches wide, each being wound with fourteen conductors of 0.37 inches x 0.28 inches compressed copper strand. The internal diameter of the armature is slightly



SELF-CLOSING GAUGE COCK, MADE BY THE LIBBY MANUFACTURING COMPANY, NEW YORK

over 16 feet, and the width of the core is 16 inches. Cast-iron collector rings and carbon brushes are used. The net weight of the alternator is 135,000 pounds.

A Self-Closing Gauge-Cock

ONE of the latest inventions in the line of gauge cocks is shown in the annexed illustration, which represents a self-closing cock recently brought out by the Libby Manufacturing Company, of New York City.

The cock is made in three parts,—body, handle and stem, the last being connected to the handle which, in turn, is engaged to the body of the cock by having a thread of large pitch cut in both body and handle. The seat being in the body of the cock and is closed by the steam pressure acting with the stem against the body, thereby making an absolute tight joint. When the chain attached to the handle is pulled, the latter turns and advances the stem which opens the cock; on releasing the chain, the torsion of the spring will move the handle back to its original position, closing the cock.

Electrolytic Drilling

DRILLING by means of the electric arc has been used to some extent, notably in drilling armor plate. In this process, the plate to be drilled is one electrode, connected to one terminal of a generator, and a carbon electrode connected to the other terminal of the generator is held against the plate. Another process is to soften the plate locally by an electric current, making the place to be drilled the resistance in the electric circuit, and then drilling out in the ordinary manner.

Sherard Cowper-Coles has undertaken some experiments, described in the "Electrochemist and Metallurgist" of London, with the object of ascertaining whether it is possible to drill and slot holes electrolytically at a sufficiently rapid rate to be of commercial value. Such a process would have many advantages, as holes of any shape could be drilled in hardened armor plates and could be pierced without drawing the temper.

In the first experiments the electrolyte was projected on the iron to be drilled, a current of electricity being caused to flow from the metal to be drilled through the jet of liquid, and thus back to the generator. This method was found to be fairly satisfactory, but the holes were not sufficiently true. A different nozzle was then constructed, the electrolyte being rapidly circulated through the nozzle, and round a baffle plate placed down the center, so as to get rapid circulation. A pointed rod, fitted in a gland, was so arranged as to be near the end of the baffle plate. In this apparatus the rod forms the negative electrode, on which the iron is deposited in a powder, due to the high current density, and is washed away by the rapidly circulating electrolyte. The end of the nozzle is fitted with a removable rubber washer, the shape and size of the hole to be drilled are determined by the shape and size of the rubber washer. Some of the best results when drilling iron have been obtained with a solution of sulphuric acid. Good results have also been obtained with ordinary salt water.

As in the case of the arc drilling device, the plate is made one electrode and the point rod the other. The parts can be so arranged as to work from both sides of the plate to be drilled, the plate being made one electrode and current flowing from it to the two nozzles. The electrodes may also be mounted concentrically in a revolving head similar to that of a lathe. This gives to the electrode points a circular motion which is adaptable to cutting out large holes, as, for instance, manholes in boiler plates. Of course, for drilling a small hole, the electrodes are forced straight through without circular motion.

Personal

Professor W. E. Goldsborough, chief of the Department of Electricity at the St. Louis Exposition, who has contributed to this issue an article on the St. Louis electrical features, graduated from Cornell University with the degree of M. E. For a time he had charge of the electrical work of the International Correspondence Schools at Scranton, Pa. In 1893 he was appointed Professor of Electrical Engineering of Arkansas University, at Fayetteville. The following year he was called to Purdue University as associate professor of electrical engineering. In 1896 he was made full professor, and in the succeeding year was elected director of the electrical laboratory. He has been connected with various expositions since 1893, having been a member of the International Electrical Congress at Chicago, and was connected in an official way with the expositions of Omaha and Buffalo. He was one of the delegates of the American Institute of Electrical Engineers at the Paris Exposition in 1900. He is a member of numerous engineering and scientific societies, being one of the board of managers of the American Institute of Electrical Engineers, a member of the Institution of Electrical Engineers of England, the Franklin Institute, the American Association for the Advancement of Science, the Society for the Promotion of Engineering Education, the National Electric Light Association, the American Electro-Chemical Society and the American Electro - Therapeutic Association. Prof. Goldsborough is well known to the engineering and scientific world

through numerous contributions to the "Transactions of the American Institute of Electrical Engineers," and papers read before the National Elec-

W. E. GOLDSBOROUGH

tric Light Association and other engineering societies, as well as many contributions to the scientific and electrical press.

President Edgar, of the National Electric Light Association, has asked Dr. S. S. Wheeler to act as chairman of the committee to examine the papers of those competing for the gold medal offered by past-president Doherty for the best paper on underground construction, to be presented at the twenty-seventh convention of this association. Dr. Wheeler has consented to serve, and the other members will be Mr. Louis A. Ferguson and Mr. H. G. Stott. All of these gentlemen are excellent authorities on the subject, and it is hoped that the papers will be of a character to make their work a most interesting one.

S. S. WHEELER

Edwin R. Rice, Jr., has been elected during the past week a director of the General Electric Company to fill the place left vacant by the death of William C. Whitney. Mr. Rice is a director in several street railway and electric lighting companies, and is already vice-president of the General Electric Company.

The Clarkson School of Technology has just reprinted in pamphlet form, as part of its "Bulletin," the admirable Founder's Day Address, "The Success of the Educated Man," delivered by Dr. F. A. C. Perrine, president of the Stanley Electrical Manufacturing Company, of Pittsfield, Mass. Dr. Perrine claimed that the modern "humanities" are really the great engineering arts, and that the work of the educated engineer has elevated the entire world up to more pleasant places for mankind to live in.

Mr. B. G. Lamme has been promoted from acting chief engineer to chief engineer of the Westinghouse Electrical and Manufacturing Com- of Pittsburgh.

H. W. Buck, electrical engineer of the Niagara Falls Power Company, recently delivered a lecture before the Electric Club, of Pittsburgh, on "The Installation of Electric Cables."

Edwin Reynolds of Milwaukee, consulting engineer of the Allis-Chalmers Company, celebrated the seventy-third anniversary of his birth on Wednesday, March 23. He was the recipient of hearty congratulations by officers and employees of the company with which he has been identified for so many years. The directors of the German-American Bank, of which Mr. Reynolds is president, presented him with a bouquet of seventy-three American Beauty roses.

EDWIN REYNOLDS

Oscar T. Crosby, the electrical engineer and explorer, has returned to Paris from a trip to Central Asia where he explored almost inaccessible parts of Turkestan and Thibet. On his way to Thibet Mr. Crosby skirted Afghanistan, visited Chinese Turkestan, and later, traversed Kashmir and the Karakorum caravan route, probably one of the most difficult used by human beings to India. Mr. Crosby in 1900 explored by way of Abyssinia unknown regions of the upper Nile

John B. Allan, general manager of sales of the Allis-Chalmers Company, and Arthur West, assistant chief engineer of the company, have resigned. Both will take holiday and recreation trips before resuming business connections.

William L. Saunders, vice-president of the Ingersoll-Sergeant Drill Company, New York, has been elected president of the company in succession to the late William R. Grace. George R. Elder, manager of the manufacturing department, has been elected third vice-president.

W. L. SAUNDERS

Ervin Dryer has resigned his position in connection with the Westinghouse Electric and Manufacturing Company, and has accepted an appointment with the Allis-Chalmers Company, of Chicago. Mr. Dryer's connection with the Westinghouse Company extended over a period of sixteen years. He is one of the most competent salesmen in the electrical and mechanical field, and his wide acquaintance throughout the western part of the United States will be of great service to the Allis-Chalmers Company in the extensive new developments which they have undertaken. Mr. Dryer has already entered upon his new duties. His headquarters will be at the Allis-Chalmers Company's offices in the New York Life Building, Chicago. He will give his attention to their engine work, as well as to the sale of Bullock electrical apparatus, which the Allis-Chalmers Company now control through their acquisition of the Bullock Electrical Manufacturing Company, of Cincinnati.

Mr. W. F. Warden, president and general manager of the Burt Manufacturing Company, Akron, Ohio, makers of the Cross oil filter and the Burt exhaust head, sailed on April 15 for Europe. Mr. Warden goes in the interest of his company, which has a large foreign trade in all the principal countries of the world. In Mr. Warden's absence Mr. J. Asa Palmer, secretary of the company, will have full direction of its affairs.

Francis B. Allen, who has been second vice-president of the Hartford Steam Boiler Inspection & Insurance Company for nineteen years, was elected first vice-president at the recent annual meeting of the company. The directors did not fill the place of president, vacant through the death of J. M. Allen, nor that of second vice-president.

J. J. O'Brien, who for more than fourteen years has been in the auditing, accounting and financial depart-

ments of the Chicago offices of the General Electric Company, and for the last few years has occupied the position of cashier and chief clerk, has resigned to take the position of general auditor with the engineering firm of H. M. Byllesby & Company, New York Life Building, Chicago, Ill.

Edward Weston, of Newark, N. J., in recognition of his work in electrical science, both for investigations and inventions, has received the degree of LL. D. from McGill University.

Lamar Lyndon, of New York, has been retained as consulting engineer by the New York & Honduras Rosario Mining Company, San Jacinto, Honduras, to lay out a hydro-electric power and transmission plant.

James Ross, of Montreal, president of the Mexican Light & Power Company, Limited, which is building a huge plant at Necaxa to generate power for transmission to Mexico City and the El Oro mining district, is at present in Mexico inspecting the progress made in the work. He is accompanied by F. L. Wanklyn, formerly vice-president and general manager of the Montreal Street Railway.

J. H. Waugh, of Pittsburg, Pa., has severed his connection with the Westinghouse Electric & Manufacturing Company and has assumed the active management of the business of the Electrical Equipment & Supply Company, of that city.

Mr. Frank W. Frueauff, auditor of the Denver Gas and Electric Company, has been asked to report on office methods and accounting at the twenty-seventh convention of the National Electric Light Association, to be held in Boston May 24 to 27. As Mr. Frueauff is familiar with the up-to-date methods of keeping central station accounts, including modern devices for saving time and insuring accuracy in office work, his report promises to be a valuable addition to the programme of the meeting.

Charles F. Case has been appointed district sales manager of the Nernst Lamp Company's newly opened office at 47 State street, Detroit, Mich. The territory embraced by this office is the lower peninsula of the State of Michigan, the northwestern part of Ohio and the northeastern part of Indiana.

Rudolf Wieser has been commissioned by the Mexican-American Company, 49 Wall street, New York, to look over the ground with a view to constructing an electric railway between Guadlajara and Lake Chapala, Mexico, a distance of about 40 miles. The Mexican-American Company also proposes to install some lighting plants in the State of Jalisco. E. H. Talbot is president of the company.

American Institute of Electrical Engineers' Election

AT a recent meeting of the American Institute of Electrical Engineers in New York the board of directors placed in nomination the following ticket containing the names of the proposed officers to be voted on at the annual election in May:—

For president—John W. Lieb, Jr., New York.

For vice-presidents—W. E. Goldsborough, St. Louis; John J. Carty, New York; Samuel Reber, Washington, D. C.

J. W. LIEB, JR.
THE PROSPECTIVE NEW PRESIDENT OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

For managers—Henry G. Stott, New York; Louis A. Ferguson, Chicago; J. G. White, New York; S. S. Wheeler, Ampere, N. J.

For treasurer—George A. Hamilton, New York.

For secretary—Ralph W. Pope, New York.

The directors' nominations are usually equivalent to an election. Mr. Lieb, the probable president, is now a vice-president of the institute. He is third vice-president and associate general manager of the New York Edison Company and one of the best known of the central-station managers and engineers of the country.

Arthur Warren

Chief of Publicity for the Allis Chalmers Company

WITH the large extensions to the field of operations of the Allis-Chalmers Co., of Chicago, recently noted in these columns, it became desirable to create a Department of Publicity, and for this purpose the company has been fortunate enough to secure the services of Mr. Arthur Warren, whose achievements in technical and popular journalism, and in the promotion of great industries, are well known in America and in Europe. For Mr. Warren is a journalist and an author, as well as a business man, and when he has a story to tell he gets at the heart of the matter without a waste of words. He is a native of Boston, and was educated in that city and in Europe. His qualifications for his work are unique. Before he became a journalist he had some machine-shop practice, so that he might become familiar with the mechanical end of a business at whose commercial end he was seeking a position. He got his position and it sent him traveling. He is a keen observer. What he saw interested him, and he began to write about people and places and things. Then his services were sought by the press, and after a sojourn in Europe he joined, in January, 1883, the staff of the "Boston Herald," which is one of the most powerful, as it is one of the best-edited newspapers in the United States. He became the "Herald's" chief special writer. People and places and economics were his subjects, and he was also engaged with conspicuous success in literary and dramatic criticism. On industrial themes he wrote much, and his articles were widely quoted.

Mr. Warren has an enormous capacity for work, but he works easily. His colleagues used to say that he always appeared to have plenty of time on his hands, and yet he was all the time keeping up the "Boston Herald" work, editing a local weekly and writing for New York papers. It is characteristic of him that he never makes a parade of being busy. Everybody will remember his story of the business man who grants five minutes for an interview and spends a quarter of an hour in telling how pressed he is for time. Mr. Warren does not talk much of what he is doing, or of the methods by which he does it. But the things are done.

In December, 1888, Mr. Warren went abroad as London correspondent of the "Boston Herald." That was in the days when being a London correspondent meant gaining the blue-ribbon of American journalism. Geo.

W. Smalley was still representing the "New York Tribune," and Harold Frederick the "New York Times." Now Mr. Smalley is representing the "London Times" in New York and Washington, his London successor being Mr. I. N. Ford, who worthily maintains the great traditions of the "Tribune." Mr. Ford, of the "Tribune," and Mr. Chamberlain of the "Sun," are the only members of the famous group of London correspondents who remain.

Mr. Warren remained nine years in London for the "Boston Herald." He made a high reputation and a world-wide acquaintance. His London home he still retains, spending in it a few weeks of every year. It is a place that became notable as a center for those who were really "doing things" in the world of politics, industry, literature and art. Mr. Warren's activity was shown by his contributions to the journals and magazines on both sides of the Atlantic. The studies which he made of industrial conditions in Europe and America furnish many a text for public workers. His book on "The Charles Wittinghams, Printers," published by the Grolier Club, of New York, is a notable contribution to the history of printing and the art of making fine books.

ARTHUR WARREN

In November, 1877, Mr. George Westinghouse invited Mr. Warren to return to the United States, offering him an important place on his executive staff, new plans and great extensions of operation looming large in the brain of the great inventor-manufacturer. So Mr. Warren organized the Westinghouse Companies' Publishing Department, with headquarters in New York, Pittsburgh, and London, and, as a contemporary writer has said, " his record of solid achievement in the way of publicity of the best kind in articles and advertising, in pamphlets and diplomacy, has never been surpassed."

In February, 1894, Mr. Warren resigned his Westinghouse connection after a period of rather more than six years of successful work which had kept him busily oscillating between the Continents. He had planned to return to the scenes of his former literary and editorial activities, and had engaged his passage for London for the end of March. But early in March Mr. Edward D. Adams, the well-known New York financier, who is chairman of the executive committee of the Allis-Chalmers Company, sent for him and offered him the post of Chief of Publicity for the great organization under its new regime. Mr. Warren is a member of the Engineers and Lawyers Clubs in New York, and of the Automobile and Whitefriers Clubs of London.

Trade News

At the annual meeting of the General Electric Company to be held early in May, according to Wall Street report, it is probable that the capital stock will be increased $3,325,000. On this subject the new York "Commercial" recently remarked: "This new stock, together with $1,062,600 of stock now held in the treasury, will be offered to stockholders at par to the extent of 10 per cent. of their holdings. The authorized capitalization of General Electric is $45,000,000, of which $43,937,400 are understood to be outstanding. This leaves $1,062,600 of the stock in the treasury. This stock in the treasury, together with the $3,325,000 of new stock to be authorized, will make $4,387,600. This is practically 10 per cent. of the amount of capital stock now outstanding. As General Electric is selling around $170 a share, the rights to subscribe to the new stock issue will be valuable. It has not been announced for what purpose the funds to be derived from this new stock issue will be used. It is understood that a part will be used to extend the foreign business of the company. The advance orders so far received indicate that the business of the General Electric this year will be much the largest in its history. The orders received are said to be largely in excess of the orders received during the corresponding period of last year. It is understood that E. W. Rice, Jr., will be elected a director to succeed the late William C. Whitney. The other retiring directors will be re-elected."

A doubling of its capital stock, which has been $1,000,000, is announced by the Crocker-Wheeler Company, manufacturers and electrical engineers, of Ampere, N. J. The company was organized in 1892 by Dr. Schuyler Skaats Wheeler and Prof. Francis B. Crocker, on a relatively modest basis. It now has fifteen branch offices from Boston to San Francisco, and does one of the largest businesses in the world in electric power apparatus. The capitalization was several times increased, until in 1899 it had become $1,000,000. In view of the rapidly expanding business, the stockholders have now decided to increase this amount to $2,000,000. The company also announces the opening of a new branch office on May 10, in the Hibernia Bank Building in New Orleans. Mr. W. P. Field, of the St. Louis office of the company, will be the representative in Chicago.

The Hercules Float Works, Springfield, Mass., makers of the Hercules seamless floats for power and heating plants, sustained a considerable loss by fire on March 30. The new plant on Franklin street was nearly ready for occupancy, and the company expected to move on April 15. The fire has delayed preparations for the change materially, but the company feels assured that by May 10, at the latest, they will be settled in their new home.

The Canadian Westinghouse Company, Limited, of Hamilton, Canada, have recently engaged Mr. C. C. Starr, who was formerly connected with the firm of John Starr, Son & Company, to act as their representative in the Maritime Provinces, with headquarters at 134 Granville street, Halifax, Nova Scotia. The Maritime Provinces are included in the district of the Canadian Westinghouse Company's Montreal office, and Mr. Starr will be consequently an attache of that office.

The Brown Corliss Engine Company, of Corliss, Wis., have just received an order from the Phillips Insulated Wire Company, of Pawtucket, R. I., for one of their 14 inch x 28 inch x 42 inch tandem compound con-

densing Corliss engines and one 18 inch x 36 inch x 48 inch engine of the same type.

The Reeves Pulley Company, of Columbus; Ind., announces, among recent sales, six of its variable speed gears to the Diamond Match Company, at Barberton, Ohio, whose factory at that place is ultimately to be equipped with these gears throughout. Fifty of the machines have also just been sold to the Philadelphia office of the B. F. Sturtevant Company, who will use them on their rotary cement kilns and coal conveyors.

The Henry R. Worthington Hydraulic Works, at Brooklyn, N. Y., are shortly to be removed to Harrison, N. J., to occupy the new $2,000,000 plant of the International Steam Pump Company, now nearly completed. The Brooklyn site consists of two city blocks, or about four and one-half acres, while the Harrison plant is located on a 35-acre tract and contains 18 acres of floor space. The Worthington Company is one of the oldest and largest manufacturing concerns in Brooklyn, having been founded in 1843 by Henry R. Worthington, the inventor of the duplex steam pump and other hydraulic devices. About 2,000 men are employed in the South Brooklyn works, and many will undoubtedly go to the new plant at Harrison, which will accommodate from 5,000 to 6,000 men. The Brooklyn works will probably be sold, the company having already disposed of its large foundries at Elizabethport, N. J.

The Brooklyn Rapid Transit Company are planning to go ahead with the erection of their proposed new power station on Kent avenue, Brooklyn. The plant is to be one of the largest in New York, the present arrangement being for the installation of apparatus aggregating 100,000 horsepower. It will be remembered that the company received preliminary estimates for the engines, boilers, generators and other equipment last spring, but as yet no important contracts have been closed. One of the main reasons for the management holding off has been that they are seriously considering the installation of steam turbines in place of reciprocating engines, as were first intended. Should this matter be settled in favor of the turbo generator, it is intended to install units of 10,000 horse-power each. The General Electric, Westinghouse and Allis-Chalmers companies are figuring on the contracts, which, it is expected, will be closed soon.

The California Gas & Electric Corporation has purchased the systems of the Standard Electric Company, of California, and the United Gas & Electric Company. These latter companies have been supplying electric power to twenty of the principal counties of the State of California. The Standard Electric Company's main plant is in Amador county. It supplies Sacramento and San Joaquin counties, joining with the United Gas & Electric Company in supplying the counties around San Francisco Bay, its lines running through San Jose up the west side of the bay, into San Francisco.

The Nernst Lamp Company has recently removed its Boston office from 131 State street to 501 Atlantic avenue. The office will, as heretofore, be in charge of Mr. Geo. C. Ewing, as district manager, and will carry a complete stock of Nernst lamps and supplies, insuring prompt service to customers.

The Standard Underground Cable Company, of Pittsburgh, announces the recent opening of a branch office in the Security Building, St. Louis, Mo., in charge of Mr. W. A. Caldwell, who has had a number of years' experience with the company in both the construction and sales departments.

The Maxfield-Francke Company, manufacturers of the Francke four-ported engine, has removed its offices from 120 Liberty street, New York, to 136 Liberty street, the Electrical Exchange Building.

The National Electric Company, successors to the Christensen Engineering Company, have inaugurated a new department at their plant. Free dinners for the officers, the employees in the executive offices and the heads of the departments will be served daily at the expense of the company. Two pleasant dining rooms, a butler's pantry and a kitchen have been fitted up in the new office building recently erected at the company's plant near Riverside Park. The dining rooms and kitchen are located on the second floor of the building. One dining room is for the officers of the company and their guests and business men from other cities who come to Milwaukee to inspect the plant. It is expected that the officers will get into closer personal touch with one another by dining together each noon, and that many informal executive sessions for the discussion of the company's interests will be held over the coffee cups and cigars. The second dining room will be for the employees of the offices and engineering department. The chef will have entire charge of the preparation of the dinners, which will be served promptly at noon. There will be no charge whatever to the employees for the dinners, but the company's object is not purely philanthropical, as it is believed that the plan will be mutually beneficial to employer and employed. The company expects to be more than repaid for the expenditure in the increased interest which their employees will take in their work and in the time which will be saved. The employees now have an hour and a half for the noonday luncheon, but with dinners served at the plant, it is expected that the men will be ready to return to their desks at 12:45 instead of 1:30 o'clock. In the additional work which will be accomplished in this time, and in the increase of personal interest which it is hoped will result from the social hour, the company expects to find its recompense.

Fairbanks, Morse & Company, of Chicago, have engaged Mr. M. Greenwood formerly Pittsburg manager for the International Steam Pump Company, to look after their steam pump business in Pittsburg territory.

The Magnet Wire Company have removed to new offices at No. 42 Broadway, New York.

The Nernst Lamp Company have established a branch office auxiliary to the Pittsburg district office, at 537 Scofield Building, Cleveland, Ohio, in charge of Mr. J. C. Wright. This office will carry a stock of Nernst lamps and renewal parts, insuring prompt attention to all orders in this district. The Nernst lamp is becoming widely introduced in the New England district. The company has recently received two large orders, one from the Saco & Pettee Machine Shops, Biddeford, Me., for 575 three-glower lamps, and one from the Arlington Mills, Lawrence, Mass., for 600 lamps of the 44-watt type. The second order comes in the form of a testimonial, as quite a large installation of Nernst lamps had already been made by the latter company.

One of the many benefits of the use of the telephone in rural districts is the check upon the lawless tramp. In one county in Indiana the tramp nuisance is said to have been largely mitigated by the prompt enlistment of the Sheriff's aid by telephone. Out there it is the belief that where there are telephones tramps cannot abide.

FIG. I.— THE TRACKLESS TROLLEY IN GERMANY. SINCE THERE CAN BE NO RAIL RETURN, THE DOUBLE-TROLLEY SYSTEM MUST BE USED

Trackless Trolley Omnibuses

OMNIBUSES and country road wagons driven electrically, from overhead wires and trolleys, appear to be the fashion abroad just now. Several different kinds have made their appearance within the past year, developments apparently of an idea first advanced, as it is now recalled, four or five years ago somewhere in the United States. The short line equipped at that time involved the use of a double-trolley arrangement, two wires being run about 17 feet above the ground and about 18 inches apart. The trolley device consisted of a metal frame with two overrunning trolley wheels, with locking wheels underneath which prevented the top wheels from leaving the wire without obstructing the free passage of the frame over the supports on the poles. On the lower wire a similar device was used, and both sets of trolley wheels were connected by an insulated pantograph arrangement which provided for unequal tension on the trolley wires. Connection between the trolleys and the wagon was made by cables running on to an automatic reel on the wagon. This permitted the cables to run out a few hundred feet if necessary, or wound them up to a short length, giving the wagon considerable freedom in direction of travel, enabling it to readily turn out of the way of obstacles and to follow twists and turns of the road without difficulty, even though the pole line took a somewhat different and possibly more convenient course. The current was led to a 2 H. P. motor on the wagon.

This brief recapitulation of particulars of that early line has a renewed interest in connection with what has more recently been done with two overhead electric trolley omnibuses in the suburbs of Paris, and which, it is thought, may help materially in solving the transportation problem in sparsely populated districts unable to support the ordinary system of electric tramways. It may be said here, by the way, that running electric omnibuses with overhead trolleys was tried at the Paris Exhibition in 1900, but failure in that instance was ascribed to the fact that the trolley with its connections had to be towed behind the bus, and variations in the speed and in the line traversed by the bus caused jamming and other difficulties. In the new route, which is said to have been in operation for some time, the trolley running on the overhead wires is self-propelling, being arranged to run with a three-phase motor, the transformed current coming from the omnibus, so that the speed of the self-propelling trolley varies directly with the progress of the bus itself, and thus it travels at a regular distance in advance of the bus. The self-propelling trolley weighs 44 pounds, and the connection between it and the bus, as in the earlier trials above recorded, is in the form of a cable sufficiently long and flexible to allow the bus to go at will from one side of the thoroughfare to the other. The length of the route on which the system is at work is over 3 miles. The vehicles weigh, with their load, $3\frac{1}{4}$ tons, and carry 18 passengers, making the trip of 3 miles in twenty minutes.

FIG. 2.—ONE OF THE OMNIBUSES HAS ITS TROLLEY POLES PULLED DOWN, SO AS TO LET THE OTHER VEHICLE PASS

A still later and better type of trolley omnibus, however, would seem to be the one turned out by the well-known Siemens-Schukert Works, of Berlin, one of the largest electrical firms in Germany. Illustrations of this are given on this page and the one opposite. In this omnibus we find something much like the conventional form of trolley pole used in street car practice,—a decided improvement over the self-propelling trolley in the French omnibus line. The trolley poles are so swivelled as to allow considerable lateral movement to the omnibus and enable it to easily pass obstructions on the road, as in Fig. 1 for example.

Fig. 2 illustrates a case where two trolley omnibuses have met. One of them, therefore, has to come to a stop and its trolley poles are pulled down so that the other wagon can pass; after that it proceeds on its way. As to the general character of the vehicles, the pictures practically tell their own story. Sometimes the motor wagons have trailers coupled on, the latter serving for baggage of the passengers carried and sometimes for general express matter.

A number of lines are now in operation in different places with omnibuses of this type, and their service is understood to be giving general satisfaction, a speed of about 15 miles an hour being maintained along the country highways. In the United States the trolley street car has evidently been too formidable a competitor for its trackless counterpart; possibly, too, there have been other electrical interests to restrict its development. But in Germany its commercial success seems to be an assured thing.

The omnibus line is obviously economical in the matter of equipment. There are no rails, no specially prepared roadbed, and no permanent way maintenance expenses. Besides, there are no stray return currents to be taken care of, and no possible electrolysis of gas and water pipes.

Invar is the name of a new alloy, which, it is reported, contracts upon heating instead of expanding.

A Summer School for Artisans

A SUMMER school for artisans will be opened by the University of Wisconsin on or about July 1, the sessions to extend over a period of about six weeks. The course will include the study of steam, gas and other heat engines; applied electricity; mechanical drawing and machine design; materials of construction, fuels and lubricants, and shop work. In applied electricity the subjects taken up will be theory of direct and alternating current dynamos and motors; the operation and methods of testing electrical machinery, batteries, transformers and other apparatus, photometry, and calibration of instruments. The entire expense during the six weeks' term, including living and school expenses, may be fairly estimated at $50.

Asuncion, Paraguay, has an electric lighting plant, though the lamps have not yet been put up. If successful, it will be extended so as to supply electric power for general service.

Electric Lighting

From Small Water Powers with High Heads

By THORBURN REID

MANY years ago, when I was a very small boy, I built a dam, a canal and a water-wheel in a small meadow brook near my home in the country. The fall obtained was about 12 inches; the canal, about 6 inches by 6 inches in cross-section, was about 6 feet long, being dug out of the soft earth bank at the side of the stream. At the lower end of this canal a water-wheel was erected, consisting of a wooden shaft about 1 inch in diameter and 12 inches long, with ends whittled down to allow of their being inserted in gimlet holes in two upright posts driven into the earth, wooden paddles being inserted into gimletholes in the middle of the shaft. This wheel was placed just over the fall at the lower end of the canal, and constituted the old-fashioned, lazy, easy-going "undershot."

My water-power plant never served any useful purpose in furnishing power, and my interest in it practically ceased with its completion. As a boy, my pleasure lay mainly in doing the work, and considerations of first cost, operating expenses, market for power developed, in a word, the commercial, as distinct from the purely engineering, elements, never intruded themselves into the problem to complicate it and disturb my happiness.

My perfect contentment in the work, wherein I was laborer, engineer, mechanic, and manufacturer all combined, has lingered in my memory with so pleasant a fragrance that to this day I can never pass a stream, be it ever so small and insignificant, without scanning it for possible sites for small water-powers.

Some years ago during an engineering trip I came across a number of small water-powers, probably from 50 to 100 H. P. each, some of which were used to drive mills, and others to supply light and power by electric transmission to various small towns and villages in the vicinity. Instantly it flashed into my mind that here were my boyish games being played by grown men in sober earnest, and that I might play them over again with all the old pleasure, much enhanced by the far larger scope of the work and its practical usefulness. As my time was then occupied with other work, much of it being concerned with water-powers of far greater capacity, but little attention could be devoted to following up this interesting possibility; but the few cases that I was able to work out showed such good results as to indicate a wide field of possible activity, which, as far as I know, has scarcely been exploited at all.

Perhaps the most interesting case was one upon which I stumbled while on a vacation at one of a number of mountain lakes. A small brook, fed by springs up on the mountain side, tumbled down a rocky bed through the woods and emptied into the lake a score of yards from a summer hotel. Having no instruments with which to measure the available fall or with which to obtain the flow of the stream, these had to be improvised from crude materials at hand. A carpenter's square and a stone hung on a string served for a level, one leg of the square being held in a vertical position by means of the stone and string plumb line, while I sighted along the other to a rod held for me by an obliging rodman, or rather rodwoman, my wife being my interested and more or less amused assistant. By these primitive means I found I could get a fall of about 150 feet in a horizontal distance of about 300 yards, measuring from the point where I had decided to place my dam down to the surface of the lake.

After much searching, a comparatively quiet stretch of stream was found, with the banks straight and the bottom of even depth, and the flow of the stream was measured by the float method. Twigs were placed in the stream at various distances from the bank, and the time required for them to pass from one string stretched across the stream to another parallel to the first and about 15 feet below it, was taken. The area of cross section of the stream was then carefully measured at several points between the strings and an average taken.

Owing to the smallness and shallowness of the stream, it was recognized that a comparatively large part of the water would be retarded by the irregularities of the bottom, and the cross section was, therefore, divided into ten imaginary channels, and the velocity having been determined for each, a large factor of safety was used, increasing as the depth of the channels decreased, and then the flow was calculated for each channel separately and all were added together. That the weir method of measurement would have been preferable to this in point of accuracy is undoubted; but I had neither the time nor the tools to build the necessary dam and weir, however much I would have enjoyed my old game of dam building.

The flow thus determined, after making liberal allowances for inaccuracies in the method of measurement, came out at about 1 cubic foot per second. Inquiry among the natives revealed the fact that the stream was very regular in its flow, except just after a heavy rain, and that at the time of my measurement it was about as low as it ever got to be. That its flow would be regular was to be expected, as its whole course lay through thick, virgin woods in which the accumulated mould of many years held water like a sponge when it rained and allowed it gently and gradually to seep down to the brook between rains. To afford an idea of the size of the stream, it may be noted that I jumped back and forth across it at will while getting the flow.

Allowing 15 feet loss of head from friction in the 300 yards of pipe-line that would be necessary to carry the water down to the water-wheel at the lake shore, 1 cubic foot flow of water per second was equivalent to 15.3 H. P. This again must be reduced by the loss in the water-wheel to about 11.5 H. P. available on the water-wheel shaft. This would supply about 125 16-candle-power electric incandescent lamps, and that was not enough for the needs of the hotel..

However, at the point chosen for the dam site the stream had cut out a deep ravine, with wall nearly perpendicular, varying from 30 to 40 feet in height, and cut back from the stream so as to be from 40 to 50 feet part. A dam, 40 feet high and 50 feet long, would back up the water for a dis-

tance of about 100 feet. A few measurements with a tape line and leveling rod and level (the carpenter's square and plumb line again) gave sufficient data for a conservative estimate that this pond would impound about 60,000 cubic feet of water, requiring, with a normal flow of 1 cubic foot of water per second, 60,000 seconds, or nearly 17 hours, to fill up. Thus the water flowing during the day, when few lights would be required, and, therefore, little water used, would be stored up in this pond to be drawn upon at night, when all, or nearly all, the lights might be burning at once.

In such a hotel a few lights might be burning during the day in dark places, but it is not until between 6 and 7 o'clock in the evening that any large lighting load begins to come on. From then on to about 10 or 11 o'clock the lighting load is at or near its maximum. Lights are then rapidly turned off until, about 12 o'clock, nearly all are turned off, except the few which are left burning all night in halls and such places. Thus the maximum load does not last for more than about three hours, from 7 until 10 o'clock, and then it rapidly decreases till about 12, when it reaches its all-night condition.

Sufficient water, then, to supply the maximum demand for power for four hours would be ample under such conditions; but special occasions, when a dance or other entertainment is given, must also be allowed for, when the ball-room and parlors may be lighted for two hours longer. Since, however, the lights in the dining-room, kitchen, and the rooms of those guests who are attending the ball will not be lighted, one hour longer is ample to allow for such occasions. To supply this demand there would be 60,000 cubic feet of water in the pond, plus the flow of the stream during the six hours that light was required, amounting to about 20,000 cubic feet, or a total of 80,000 cubic feet. This stored water, then, would be enough to supply three times as many lights as the flow of the stream alone would supply, or a total for six hours of 500 lights, or nearly 3000 lamp-hours per night.

Since the average number of hours burned per lamp installed would not exceed two, or at most three, this would allow for an installation of from 1000 to 1500 lamps, which was far more than the hotel required. Making every allowance for brilliant illumination, not more than 600 lamps were needed, and of these, even on special occasions, it was safe to calculate that not more than 400 would be burning at any one time.

A dynamo capable of supplying 400 lamps thus would be ample, especially as such a dynamo would have an overload capacity that would enable it to supply 500 or more lamps for an hour or two if it should ever be necessary. The hotel has accommodations for about 300 guests.

Such a plant would consist of a 25-kilowatt dynamo, direct-current, direct-connected to a 40-H. P. water-wheel of the impulse type, water being supplied to the wheel through a 12-inch wrought iron pipe 300 yards long. The dam could be made a timber crib filled with earth and stones and faced on its upper side with 2-inch timbers in two layers, breaking joints, and bolted together. Such a dam would be tight, would require little repairing, and would last for fifteen or twenty years. The power house would be a simple wooden frame building, its outside being made to conform with its surroundings, and would cost very little. The whole plant, including the dam, pipe-line, water-wheel, dynamo, switchboard, wiring, lamps, and all accessories, complete and ready to run and furnish light to the hotel, would not exceed about $6500 in first cost.

The operating expenses of such a plant would include as fixed charges, —that is, charges that are mainly independent of the length of time during which the plant is in operation,—depreciation, repairs, taxes, insurance, and interest and as variable charges, supplies such as oil, lamps, etc., and the services of an attendant.

A liberal allowance for fixed charges was $900 per year, and as the hotel was open only about three months in the year, the supplies and attendant together would come to not more than $300, or a total operating expense for the season of three months of $1200. That this cost is much greater than that of oil lamps is undoubted, but the saving in insurance and to the far greater safety of the electric system, goes far toward offsetting the added expense.

It was possible, without any extra cost, except the first cost of the motors, to use electric power in the kitchen and laundry, as well as fan motors in the hotel, and to charge the storage batteries of electric launches and automobiles, this being done during the day time when current was not required for lighting.

The cost of a steam plant to furnish the same current would come to about $6000. The operating expenses, exclusive of fuel, would be about the same as the total operating expenses for the water-power plant, and the cost of the current would, therefore, be increased by practically the whole cost of the fuel required to generate it.

The water-power plant can be run during the day for power and for light in dark places in addition to being run at night at practically no increase in expense, since water costs nothing, while running the steam plant in the day time would mean the consumption of fuel, most of the energy of which, by reason of the light load, would be consumed in engine and dynamo losses. Again, the water-power plant can be sarted by the turning of a valve, while with the steam plant fire must be lighted under the boiler and steam raised before the plant can be started. It is scarcely necessary to cite further arguments to show that the water-power plant is preferable to the steam plant for its convenience, reliability, cleanliness and safety, even if its operating expenses had been considerably greater.

This plant has been described in such detail because it presents features making for commercial and engineering success which even engineers of much experience are almost certain to overlook on account of the smallness of the stream. The particular condition that made the utilization of this stream feasible, despite the small amount of its flow, was the high head available, since the power that can be obtained from the flow of a given amount of water varies directly with the head. Again, the high head makes it possible to store up at slight expense and utilize practically the whole amount of water flowing during the day while the plant is not in operation or is running lightly loaded.

With low heads this is not generally possible, since the depth of the water above the dam would be a large part of the total available head, and, therefore, reduction in the level of the water in the pond would largely cut down the speed and capacity of the water motor, as well as the power that can be obtained per cubic foot of water. Thus with a low head the water above the dam can be drawn down only a comparatively short distance before the reduction in the available head would cause trouble. Only a foot or two of the depth of the pond can generally be utilized in such cases, and the area of the pond must be very large if it is to serve as a reservoir for much power, both on account of the small amount of power generated per cubic foot of water and because only a small part of its depth can be utilized.

This great storage capacity of small streams with high heads makes possible the utilization of many times the average power of the stream, pro-

vided this maximum power is required for only a few hours out of the twenty-four, which is nearly always the case with electric lighting plants.

Again, the use of high heads reduces the amount of water to be handled, and thus reduces the cost of dams, raceways, pipe-lines, water-wheels, etc. Finally, floods affect such plants very slightly, while the rising of the water in the tail race during the floods often very seriously impairs the total available effective head when that head is low to begin with.

In the case described above it was not necessary to buy any land or water rights, as the land through which the stream flowed from the dam to the lake belonged to the hotel; but the cost of such rights, where it is necessary to buy them, would usually be trifling, since the water would not be valuable for any other purpose, and very little land would be needed.

It is readily seen that the field for such plants as the one here described is necessarily limited to more or less mountainous regions; but it is in just such places that other sources of light and power are costly and inconvenient on account of high transportation rates, poor and hilly roads and danger from fire.

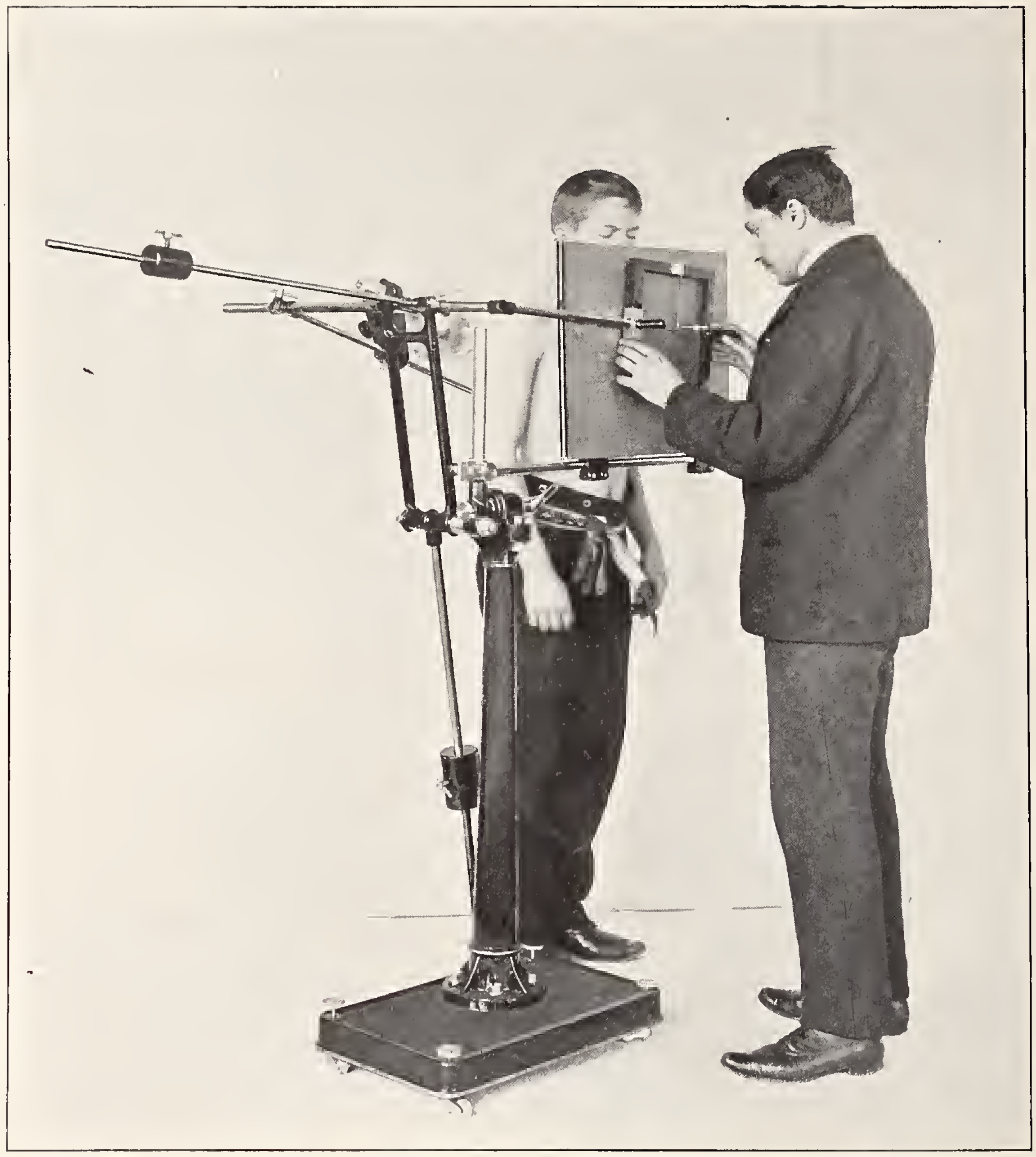
The water-powers already developed that I spoke of early in this article as having first drawn my attention to the possibilities of small streams for this purpose, all utilized comparatively low heads, and their development would not have been commercially practicable under the condition of operation for three months of the year only, as was the case with the hotel plant above described. This plant could have been in operation for the whole year, or four times as long, at a yearly cost of less than twice as much as was required for three months, since the main items of expense, the fixed charges, would be little, if at all, increased. Thus the average cost of current would have been reduced more than 50 per cent.

The writer has seen a large number of such small streams with high heads evidently capable of being profitably utilized in the manner described; but I know of but one that has been so utilized, and that one in a very imperfect and, from an engineer's point of view, very slovenly manner. The dam leaked to such an extent when I saw it that, although no water was flowing through the pipe-line, none flowed over the dam; all of the water of the stream leaked through the dam. The pipe-line was of poor design, and in a distance of about 1000 feet showed about forty leaks. In spite of these and other obvious defects, the plant did fairly well what its owner required of it.

To sum up, then, the power of small streams with high heads can, by means of storage of water, be multiplied many times whenever the maximum power is required for only a few hours out of the twenty-four. The cost of developing and utilizing such powers will be low by reason of the small amount of water to be handled and because the water of such streams and the small amount of land required are generally valueless for any other purpose. Such plants are generally reliable in operation, safe and clean, and do not require highly skilled attendance. The cost of light thus obtained will usually be much higher than by the use of oil lamps; but this will be largely offset by the attendant advantages.

In conclusion, a word of caution should be added for any one who may contemplate installing such a plant. One of the most prolific sources of trouble, even sometimes of complete failure, in the utilization of water-powers lies in the irregularity of the flow of the stream, and great care should be used to learn from all available sources what is the lowest stage the water ever reaches in the driest season. Careful measurements of the flow should also be taken and liberal allowances made for droughts.

Where much of the course of the stream lies through thick woods, its flow is likely to be fairly regular, but where its course lies mainly in the open, avoid it, since then in a dry season it is likely to run almost dry.



THE ORTHODIAGRAPH. A RÖNTGEN RAY APPARATUS FOR RECORDING THE SHAPES AND SIZES OF ORGANS OF THE HUMAN BODY

Electricity as an Anesthetic

A NUMBER of years ago it was proposed to make use of the humming noise produced by a common electric buzzer to induce sleep in cases of insomnia, but it is not know how far or how successfully the proposition was carried out. More recently M. Leduc, of France, has been conducting exeriments on the use of the electric current as an anæsthetic, which experiments were performed upon him-

self. He employed a maximum of 50 volts. The electrodes, which consisted of cotton pads moistened with a saline solution, was applied over his kidneys and upon his forehead, respectively. The current was increased gradually until it reached the maximum in five minutes. Sensation, he found, was suspended gradually, the faculty of speech being first suspended, and afterwards of the remainder of the motor system. This suspension of sensation began with numbness of the limbs. The only unpleasant feeling he experienced during the application of the current and accompanying the suspension of the faculties was the sensation of nightmare. When the current is broken, consciousness is instantly restored, and there is a sense of invigoration. The breathing is more or less obstructed, but the heart is not at all affected. Notwithstanding the apparent harmlessness of this use of the electric current, a feeling of apprehension is raised by M. Leduc's rather ominous remark, in describing his experiments, to the effect that danger to life is prevented by switching off the current immediately the breathing shows indications of ceasing.

The Orthodiagraph

A NOVEL RÖNTGEN RAY APPARATUS

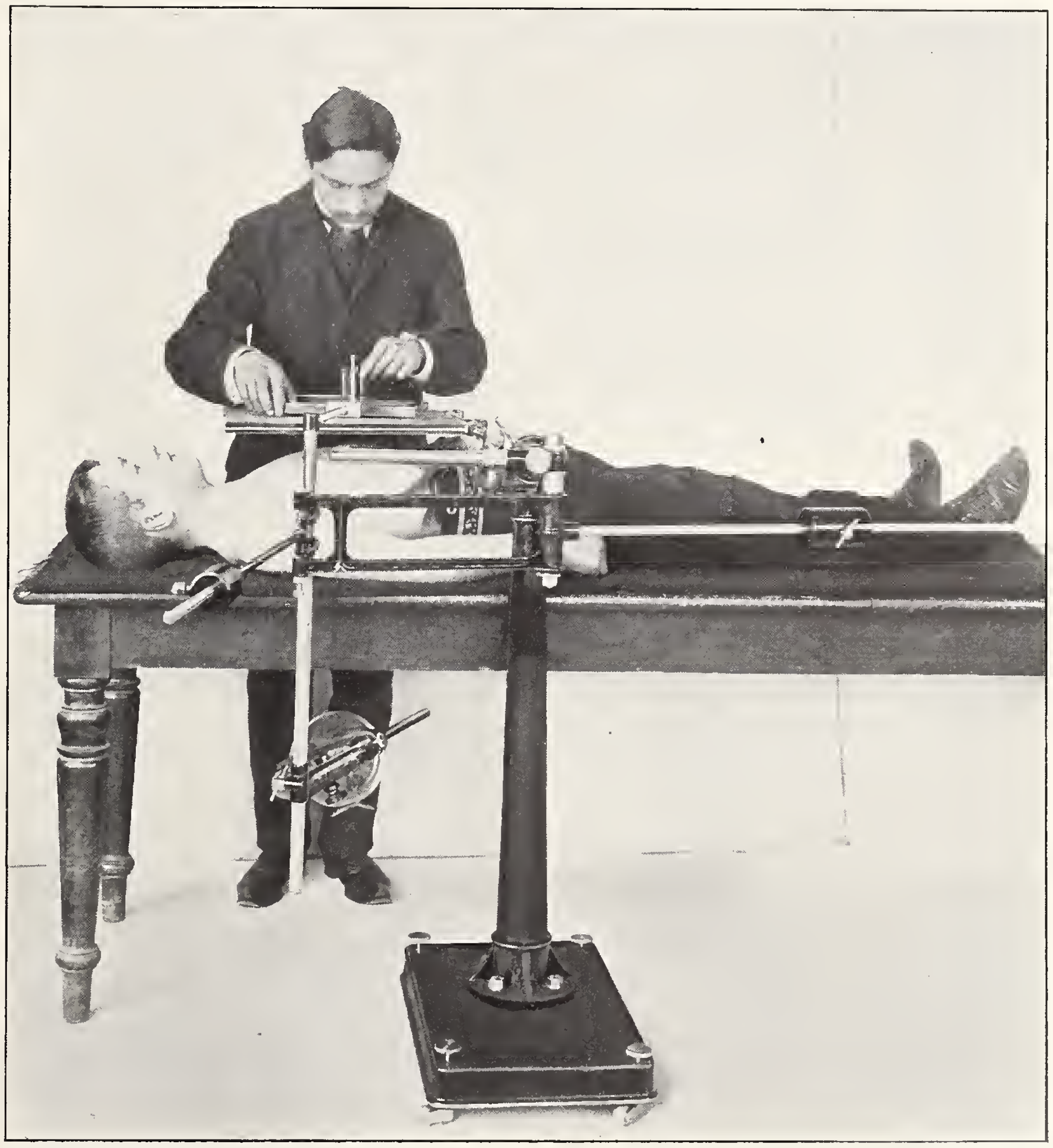
By Dr. ALFRED GRADENWITZ

IN connection with the uses of Röntgen rays in medicine, it is often desirable to obtain graphical records of the shape and size of the organs of the human body, and as Röntgen rays are given off from a very small spot in front of the cathode of the Röntgen bulb, radiating from the latter in all directions, the image of any object projected on a luminous screen or photographic plate will be a silhouette, the outline of which coincides with the points where the Röntgen rays touching the body are cutting the screen. The image of the object will, therefore, in any case be more or less magnified, it being impossible to ascertain the true size except by troublesome and not always trustworthy calculations, apart from rather material deformations.

In order to obtain a record of the object in its true shape and size, the Röntgen rays touching the body and reproducing its outline on the plate will have to be made parallel and to strike the plate at right angles. In other words, the projection from a center should be replaced by parallel projection. The Allgemeine Elektricitäts Gesellschaft, of Berlin, have just brought out the first apparatus allowing such projections in true shape and size to be obtained in any desired position of the drawing plane.

The drawing stylus fixed in the middle of the luminous screen is connected to a Röntgen bulb rigidly by a lever system between which the person is enclosed. The bulb should be so adjusted as to lie in the prolongation of the drawing stylus, when the central rays issuing from the bulb will strike the luminous screen just at the foot of the latter. Parallel movements in any desired direction, as required for obtaining a parallel projection, are effected by the system rotating around two axes parallel to each other. The drawing frame is placed in front of the luminous screen, being parallel to the latter and about half an inch away from it. The frame is fitted with a sheet of pasteboard, on which the records are made by the drawing stylus. The Röntgen bulb follows the movements of the luminous screen and drawing stylus. By drawing the latter along the outline of the organ in question, as formed on the luminous screen, the exact shape and size of the organ may be recorded. The drawing plane may be given any desired position, according as the person to be examined is either standing or lying. Drawing may also be effected immediately on the body, in which case the pasteboard is removed from the drawing plane and a special "dermatograph" stylus is used instead of a pencil. There are means also for accurately marking the position of the person, and by combining the usual method of operation with central rays and the method above described, the depth of any foreign object contained in the body may be ascertained.

The proposed electrical exhibition at Warsaw has been canceled owing to the Russo-Japanese war.



THE ORTHODIAGRAPH ARRANGED FOR EXAMINING A PERSON LYING HORIZONTALLY

The Development of Summer Lighting

Extracts from a Paper Read by E. A. Leslie before the Association of Edison Illuminating Companies.

DURING the summer season the consumption of current for residence and mercantile illumination is at its lowest ebb. The dog days are encompassed by an all-pervading dullness. Thousands of families temporarily desert their homes and join the summer exodus to mountain and seashore, while the number of hours wherein the current is utilized for business purposes is reduced to a minimum. At the same time the expenses of operation and maintenance do not decrease in the same proportion, and the results are reflected in monthly balance sheets which frequently give the officers of the electricity supply company cause for anxiety and concern.

This being true, it is a problem of vital importance to find, and if necessary create, a field and a demand for the company's surplus capacity during the summer season, in order that its load curve on July fourth may approximate if possible that of the heaviest day in December. This problem the Edison Electric Illuminating Company, of Brooklyn, has, in a measure, solved, and the manner and method of the solution were told of in an interesting way by Mr. E. A. Leslie, general manager of the company, in a paper presented a short time ago at a meeting of the Association of Edison Illuminating Companies..

Up to the year 1897, the summer business of the Brooklyn Edison Company, according to Mr. Leslie, was of the unsatisfactory character alluded to above; but early in that year it was proposed to extend the lines of the company to Coney Island, about six miles distant from its principal generating station, in an endeavor to create a demand for midsummer lighting. This project involved the expenditure of a large sum of money, and was regarded as a daring adventure, the outcome of which was problematical. It was opposed by a conservative element in the management, but after the most careful consideration the extension was finally determined upon. A high-tension transmission line was constructed, a rotary converter sub-station erected, and mains and feeders spread out as the prospects of the business then seemed to warrant.

Coney Island had for a long time been largely a paradise for fakirs, crude, and often vicious, but its natural attractions of ocean bathing, healthful sea breezes and an extensive sandy beach, combined with its proximity to the metropolitan population of upwards of four millions, promised great future development. And yet without an adequate lighting system this development was badly handicapped, and in pre-Edison days respectable visitors to the Island returned to their homes before nightfall. Since then, electric light has gradually turned night into day, and hundreds of thousands now visit this resort at night who would not have thought of doing so under former conditions. So great are the crowds during the season on all but rainy nights that transportation facilities are taxed to their utmost, and cars return from the beach heavily laden up to two or three o'clock in the morning.

This has been made possible by the extensive use of electric lighting. In fact, it is a matter of record that shortly after the inauguration of reliable service, electric lighting became an important and necessary factor in the development of gigantic places of amusement, and their most attractive feature; brightening, cleansing and improving the whole place; drawing and holding daily the largest crowds that have ever visited a pleasure resort in any country in the world.

The Brooklyn Edison Company's station load sheets show, among other things, that the company requires more machinery to handle its "summer load" than was required for its preceding "winter load," an unusual and perhaps unique reversal of the ordinary conditions. Of course, the total output is not so large in summer, neither are the financial returns as great, because the days are so much longer and the hours of burning consequently so much less; but even from the financial standpoint the results are vastly more satisfactory than would be the case if the summer lighting did not exist.

The effect of the company's activities at the Island has been cumulative, both as to its improved character and increased number of attractions and the volume of business transacted. But the company was obliged to take considerable risk at times, almost if not quite as great as the original experiment. Take, as an example, "Luna Park." When the plans for lighting that immense establishment were first laid before the company, they saw, at a glance, that the equipment necessary for the sub-station and the underground low-tension feeders and mains would cost many thousands of dollars. With nothing to rely upon as security for its investment except the well-known business ability of the proprietors, and the success which has usually attended all first-class enterprises at the Island, the company accepted the risk. The results have already completely vindicated its judgment.

Not alone as regards this particular case, but the extraordinary success which Luna Park enjoys has stimulated many others, and even now the company is in negotiation with a syndicate of capitalists who have bought land in an attractive location, and propose to erect thereon an establishment much larger than Luna Park, and install therein a prodigious number of electric lights.

What the Brooklyn Company has done for itself at Coney Island, and incidentally for the phenomenal development of that famous resort, Mr. Leslie believes, can be accomplished in greater or less degree by any electric lighting company operating in a city adjacent to a body of water, whether river, lake or sea. It is open to the doubter to argue that there is only one Coney Island, and that in this respect the Brooklyn Edison Company is peculiarly fortunate, and it is admitted; but it must be remembered that not so many years ago Coney Island was a dreary and deserted waste of sand dunes, and that, moreover, wherever similar methods have been pursued, miniature Coney Islands have sprung up and flourished, furnishing amusement to many thousands, and sensibly increasing the revenues of the wide-awake and enterprising lighting companies. This is further demonstrated by the fact that in spite of the proximity of Coney Island, with its extraordinary power of attraction, the Brooklyn Edison Company has, in conjunction with the local street railroad company, succeeded in building up near Brooklyn a number of other minor but still important summer amusement resorts, such as Canarsie and Bergen Beach, each of which is a considerable consumer of electrical energy.

About three years ago Mr. Leslie spent several months in the Middle West, and observed that Chicago and Milwaukee had their "Coney Islands;" that nearly every city along the Great Lakes had similar summer resorts, but those without ample electric lighting lacked tone, and were comparatively dull and unprofitable. A year before, while in the mountains near Easton, Pa., Mr. Leslie observed that that enterprising little city also had a "Coney Island," situated on the Delaware River, which was surpris-

ingly well patronized. "Savin Rock" is known as the "Coney Island" of New Haven. It not only draws great crowds by day, but being brilliantly illuminated holds them during the early hours of the night. Numerous other examples might be cited. The American people are always eager to be amused, and men of foresight and enterprise have long since realized that fortunes were to be made by catering to this pleasure-loving instinct. But it cannot be done on a large or successful scale without the aid of electric light. It may not be amiss here to refer to an article entitled "Decorative Uses of the Incandescent Lamp," which appeared in the February number of THE ELECTRICAL AGE. Striking illustrations were there given of some of the notable lighting effects at Coney Island referred to here.

A Canadian Export Duty on Electricity Improbable

CONSIDERING the vastness of the electrical power development on the Canadian side, the question has arisen as to whether or not the Dominion of Canada shall assess an export duty on electricity generated in its territory and transmitted across the river to the United States. As to this, "The Iron Age" says:—

In the franchises granted by the commissioners of Victoria Park, and ratified by the Ontario Government, it is provided that the companies shall from the electricity or pneumatic power generated supply power in Canada to the extent of any quantity not less than one-half the quantity generated at prices not to exceed the prices charged to cities, towns and consumers in the United States at similar distances from the Falls of Niagara for equal amounts of power and for similar uses.

In this there is an implied consent to the exportation of at least one-half the amount of power generated, and it is fair to assume that the great works have been carried on, at least by two of the three constructing companies, under the belief that the Dominion would not interfere with such exportation. Of late a feeling has been growing along the Niagara border and among the various municipalities of Ontario within the zone of prospective benefit from the Niagara development that the Government should place an export duty of about $15 per horsepower on electric power generated in Canada and transmitted to the United States. Such a duty would be almost prohibitive in its nature, so far as the border transmission or export is concerned, and the result would be that about all the power generated in Canadian Niagara would be kept at home for the upbuilding of that locality.

While such a result would no doubt form a pleasant picture for loyal Canadians to consider, the truth is, or at least the present demand makes it so appear, that it will be many years before the Canadians could hope to use the enormous amount of power now contemplated to be developed in Victoria Park. Of the three companies now holding franchises, the Canadian Niagara Power Company will develop 100,000 horse-power, while the franchise of the Ontario Power Company covers 150,000 horse-power, and that of the Toronto & Niagara Power Company 125,000 horse-power, or a grand total of 375,000 horse-power. Of course, it is far from likely that this amount of power will be available for many years; but should the three companies proceed as energetically as they are now doing, and develop their franchise rights to the utmost, Canadian Niagara would be simply swamped with power, if it were not possible to transmit some of it to market across the river in the United States. In fact, with the right of such transmission, there is no demand for such a quantity of power within the zone of profitable transmission about Niagara to-day. It has all along been pointed out that the great power plants of the Niagara Falls Power Company and of the Canadian Niagara Power Company would be of great and important usefulness to each other in case of serious accident to either, for the interchange of current service would simply increase the advantages offered by the constant current service of the Niagara power development.

The petitions that have been circulated on the Canadian side have been extensively signed, and will be presented to the government. What their effect will be remains to be seen, but it may be taken from what General Francis V. Greene has said that officials are committed to allowing a free transmission. General Greene is manager of the Ontario Power Company, and he is quoted as saying:—

"There is no such probability. So I have been assured by Canadian gentlemen who are in positions to know whereof they speak. Such a course would be folly on the part of Canada. The revenue derived from the transmission of power goes to the maintenance of the park on the Canadian side. At present the park is thus self supporting. The Canadians have all the power that they wish. If a duty was to be levied on the power transmitted over here, the park commissioners would simply lose that revenue which they now receive from the American franchises. Canada is well protected in the matter. There is a stipulation in existence which provides that if the Canadians so wish at any time they may have one-half of the power. They have no use for such an amount, so why should they not dispose of the superfluous power to the Americans? I have been absolutely assured that official and popular sentiment in Canada is strictly opposed to the imposition of any such duty."

Choosing Engines and Boilers for an Electric Plant

THE choice of power,—the price that is paid yearly for "making the wheels go round,"—presents, in the concrete, a problem of which the perplexities are not minimized when the details are set before the engineer. In a recent consideration of the subject the London "Engineer" said:

Given £10,000, how can that sum be spent to the best advantage in providing power for a cotton mill, or an electric generating station, or a mechanical engineering works? In the middle of the last century the question presented very few difficulties. Choice was limited. There was the steam engine, and nothing else; and to all intents and purposes there was only one steam engine,—a big machine, with a condenser, and a beam, and a parallel motion, and a maximum of 50 revolutions per minute, and 35-pound or 40-pound steam. The best that can be said of such an engine was that it never wore out, cost nothing for repairs, and revolved and reciprocated with the regularity of a clock. Nor had the steam user a wide range of makers from whom to get his engines. The manufacturers had to take what a few firms could supply or go without. Nor was there much substantial difference between the engines they made. They all had beams, save a few vertical engines made about the year 1852 or 1853. They all had jet condensers. The boilers were either Cornish or Lancashire. The construction of the steam engine was monotonous in its uniformity. As there was small choice, there was small responsibility. The consulting engineer who recommended a particular type

of engine could not be accused of making a mistake. One steam engine was as good as another, if not better; and the engine which a millowner had was invariably superior to that possessed by any and every other millowner.

These happy conditions have ceased to exist, and a host of competitors with a multitude of engines hunt persistently for customers. We have the results of scientific investigations embodied in iron, steel and brass. It is true that the investigation has usually been made after the engine. But the dispassionate critic will reasonably ask: How could it be otherwise? Until the facts had been ascertained by direct experiments, what could the physicist or the mathematician do? It ought to have been a source of much gratification to James Watt to be told that his invention of the separate condenser was all right in theory. Fortunately, he did not live long enough to learn that he was only a few years before his time. The physicist would certainly have deduced the separate condenser from his special knowledge of thermodynamics. In the present day, between the inventor and the physicist various forms of power have been placed upon the market, of which our grandfathers, or our earlier fathers, did not dream. The man who is now called upon to spend £10,000—or any other sum greater or smaller—on motive power, has a choice before him full of doubt and hesitation. Shall he use steam, or gas, or oil engines? If the former, what is the pressure to be? What the type of boiler? Is the engine to be triple-expansion or compound? What is the valve gear to be? Is the condenser to be jet or surface? Is there to be a pond, a cooling tower, or a well? Are the boilers to be water-tube, or Lancashire, or marine? Is the draught to be got by a chimney, or by forcing fans or by suction fans? Are automatic stokers to be used or not? How is the water to be softened? Are the engines to be vertical or horizontal; or are turbines to be selected in lieu of piston engines? In this apparently long catalogue we have really given but a few of the questions which the steam user or the engineer has to decide, questions of which, as we have said, our forefathers knew nothing.

It is a noteworthy fact that no general rule of action can be laid down, or any definite instructions derived from experience provided for the guidance of the engineer who is called in to help the steam user to a decision.. The steam user may be a big municipality, or the owner of a comparatively small mill or factory. The moral responsibility of the consulting engineer—and by this title we mean the man with whom the ultimate decision lies—is the same. In either case he must do his best for his clients. In what does this best consist? What, in a word, is best for the prospective steam user? Fortunately the answer to this question is very simple—that plant will be best that involves the smallest annual outlay, and is always ready when wanted. We are almost disposed to put the second condition first. It should certainly go first where the public are concerned. It is on the whole more important, for example, that an electric generating station should always and continuously supply current of the proper potential and quantity to its customers than it is that moderate economies should be effected. We need not labor on this point. The truth is self-evident. But this conceded, we have still a great vista of possibilities opened before the consulting or municipal engineer.

To concentrate our ideas, let us suppose that £10,000 have to be spent in providing power in a new electric light station, in a district where coal is cheap and plenty. The power that can be obtained for the sum named is moderate. We may assume that the machinery used will not break up, and so far clear the ground. What is the more likely to comply with the broad conditions which we have laid down—a steam engine or a gas engine? Let us suppose the former is thought best. What type of engine shall be used, piston or turbine? It seems to be almost impossible to arrive at the truth concerning the annual cost of power produced by any type of engine. Deal with figures how a correspondent may, there is always ready some one else with another set of figures to upset the conclusions of the first. Take, again, the question, which shall it be, superheaters or economizers, or both? We must once more fall back on the old Irish saying: "One is as good as the other, and better;" or, to put it in another way, whichever the engineer adopts, he will be sorry or glad, as the case may be, that he did not have the other.

Out of all the turmoil it seems as though one fact, and one only, comes always to the top. It is the small part relatively that the mere cost of fuel bears to the total cost of power. Even at the very high price of 18s. 6d. a ton in the furnaces, one penny buys about 10 pounds of coal, and an engine of 1000 indicated H. P., using 2000 pounds of coal per hour, represents an expenditure of 200d., or 16s. 8d. per hour. By cutting down the consumption by half a pound, the cost would be reduced to 12s. 6d. an hour; or for a day of twenty hours, by £4 3s. 4d.; or for 300 days in the year the reduction would mean £1250.

Ostensibly this is very well worth having; but before the steam user jumps to that conclusion, and acts upon it, he will do well to ascertain the price which the reduction in the consumption of coal will cost him. It will probably represent a large outlay on boilers and engines; more space occupied; more rent to pay; more skilled labor; more risk of a breakdown; higher boiler pressure; more condensing water; more lubricants; less flexibility in the load that can be carried. We may add that in generating stations this latter factor is of great importance. Highly economical engines have always one load, and one load only, at which they do their best, and it is an open secret that very expensive engines sometimes are found to be actually more costly to run than much cheaper machinery, because the load varies.

It is, of course, impossible within the limits of a short article to do more than direct attention to the difficulties which stand in the way of the engineer who is called upon to make a selection among the claims of various types of mechanism for driving dynamos, or spinning machinery, or tools. It is not easy for any man to steer a course which he can be certain in the end was the best.

Electric Oven

IN the article entitled "Electric Ovens: Baking With Niagara Power," which appeared in the March issue of The Electrical Age, it should properly have been stated that the ovens in question, baking what is known as "Triscuit," in the large cereal food plant of the National Food Company, at Niagara Falls, were supplied by the Simplex Electric Heating Company, of Cambridge, Mass.

These particular ovens represent a most important step in the manufacture of electric heating apparatus and afford one of the most conspicuous possible practical demonstrations of the effectiveness of the Simplex Company's product, and of electric heating apparatus in particular, which in the minds of some required a demonstration similar to this to convince them that such apparatus was practical in a large way, as well as durable under continuous and regular operation. The Simplex Company have had many thousand ovens running at Niagara Falls for upwards of a year and a half, completely successful from point of endurance, uniform behavior and all around effective work for the purpose they were designed.

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The Moore Vacuum Tube Light

By JAMES BRONIS

ABOUT ten years ago, when D. McFarlan Moore undertook the production of a "wireless electric light" that would be as cool as the atmosphere, as complete in color values as the spectrum and as efficient as the light of day, he was given no encouragement by men of science who were familiar with the unsuccessful attempts of many earlier inventors. Yet Mr. Moore was confident that it lay in the power of human ingenuity to bring together those components that would efficiently produce artificial light equalling natural light in every respect.

Science will not have thoroughly mastered the laws of nature until it is possible to transform any form of energy into any other form of energy. All energy may be conveniently divided under seven heads. Not only should it be possible to transform any one of these heads into any other one, but we should know how to do it efficiently. Some of these transformations it is now possible to effect with almost ideal efficiency. Electric energy, for example, can be transformed into mechanical energy with an efficiency of 98 per cent, but when the problem is to transform electrical energy into energy in the form of light, the efficiency drops to 2 per cent.

It ought to be possible, however, to make a lamp as efficient as a motor, so that electric energy could be transformed into light just as cheaply as into power. The most commonly and widely used device of to-day for this purpose is the incandescent lamp, and there is little prospect of increasing the efficiency of this, as its principle is wrong, the lamp being a mere concentration of heat, and the only way of increasing its efficiency being to increase the temperature of the filament, which the mechanical difficulties due to the rupture of the filament make prohibitive. However, if the conducting medium be changed from a solid condition to a gaseous state, then it would be conceivable that each individual molecule could be raised to a very great heat without any resulting mechanical difficulties, because there would be no filament to break.

Thought along this line leads to the interesting parallelism of the development of the incandescent lamp and the development of the vacuum tube. In the one case the search was for a vegetable fibre that would be suitable, and in the other for a vegetable gas, but dealing with an intangible substance in the latter case made the problem far more intricate than experimenting with material substances. During the incandescent lamp development every conceivable kind of filament was carefully tried, and in the same way Mr. Moore experimented with different gases, his labors culminating a few

A COUNTING ROOM LIGHTING EFFECT. THE MOORE TUBE HERE USED IS 154 FEET LONG AND 1¾ INCHES IN DIAMETER

A DRAWING ROOM WALL AND CEILING EFFECT WITH MOORE TUBES

weeks ago in the first commercial installations of his electric light in the city of New York.

The largest of these installations is at one of the branch offices of the New York "World," consisting primarily of a vacuum tube 154 feet long, this alone illuminating the whole office. It is of interest to note that probably never before has a tube of these dimensions and character been constructed. The office is 63 feet long and 18 feet wide, with a ceiling about 13 feet high. A continuous Moore tube is placed around the room at a distance of about 3 feet from the walls and 3 feet from the ceiling. It is suspended by brass fixtures made of $\frac{3}{4}$-inch brass tubing terminating in brass rings with felt lining to receive the tube. The tube was made up of $8\frac{1}{2}$-foot lengths of glass tubing welded "in situ." The tubing is $1\frac{3}{4}$ inches in diameter, with 1-16-inch wall thickness. Many special glass-working appliances had to be invented by Mr. Moore for the work, which at first seemed absolutely impossible to accomplish. The tubing follows the contour of the room and forms a continuous lamp 154 feet long.

At the rear of the office there is an iron terminal box. The two ends of the vacuum tube enter this box and terminate in electrodes supplied from a transformer fed by a 110-volt alternating current. The transformer is of special design and of $1\frac{1}{2}$ K. W. capacity. A current of 50,000 alternations is used, being obtained from a motor-generator set in the basement, which changes over the direct current from the New York Edison mains. The motor of this set is of $7\frac{1}{2}$ H. P., mounted on the same cast iron base and direct-connected to the generator, a Moore special inductor type, 100 volts, 50 amperes, running at 1800 revolutions per minute.

On the front of the building is a double sign box of iron, with glass sides protecting signs in script type on either side reading "The World," This vacuum tubing is $\frac{3}{4}$ inch in diameter, and is mounted on a sign board with terminals on the other side forming a complete unit.

As soon as the current is turned on, the 154-foot tube immediately glows with an intense, steady white light, which completely illuminates the room. The similarity to daylight is marked, and the desks are as well lighted as in the daytime, with the additional feature of no heavy shadows being cast on account of the excellent diffusion of the light. The efficiency of the light is indicated by the statement that it is operating at 2.5 watts per candle, which, contrasted with the ordinary incandescent lamp at 3.5 or 4 watts, shows that the operation of the vacuum tube is over 30 per cent cheaper than the same amount of light produced by the incandescent lamp. It is now operating at an intensity of 6 candle power per foot of tube length.

The tube appears to be filled with a dense white smoke, and the light radiating from it is about like that coming through the white clouds on a summer day. One can stare at the tube without any inconvenience whatever. Everything in the room appears in its natural color, and the pictures on the wall and the multi-colored

time-tables in the rack are shown up very clearly. The extreme softness of the light makes the room pleasant and restful.

At night the signs in front of the building have, at a distance, a slight bluish gray tint, like the sky in winter

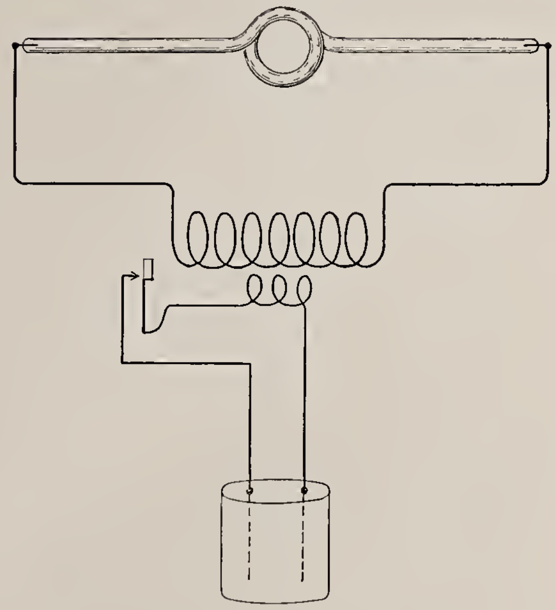


FIG. 1.—A GEISSLER TUBE

time, but on nearer approach their absolute daylight whiteness is apparent.

Another installation is at the entrance to a prominent photographic studio. There the vestibule is lighted from a vacuum tube following the walls and the contour of the 15-foot semi-circular canopy, as shown in the illustration on page 269. This is perhaps the most distinctive effect yet produced in vestibule lighting, and required some very elaborate glass blowing.

The bona fide vacuum tube has always been associated with high voltages to properly operate it, and although theoretically it has long been acknowledged to possess certain properties which indicated that it would be the light of, the future, the serious problem always presented itself of making it thoroughly commercial with its attendant high voltage. This problem Mr. Moore believes he has solved in his system by confining the high voltage entirely within the already mentioned transformer case, which is absolutely proof against danger to either life or property. This case is made like an ordinary cast iron or steel transformer case, the main difference being that space is left within for the tube terminals, the live portions of which are kept entirely within the case, so that the two glass tubes extending from it are perfectly harmless, and the only wires entering the case are the two ordinary low-potential (100 volt) wires.

Figs. 1 and 2 make the above explanations perfectly clear. Fig. 1 shows an ordinary Geissler tube operated from an ordinary induction coil in which the high-potential wires are entirely exposed, and therefore make the practical use of such an arrangement, even though the light could be made bright enough and its life long enough, absolutely impractical. But Fig. 2 shows how this seemingly unsurmountable obstacle has been completely overcome by simply having no high-potential wires exposed, and using the harmless glass tube itself as the means for transmitting the energy from within the danger-proof case. It is this danger-proof box idea that makes practical the construction of tubes of great length because on account of the danger-proof case the voltage within it can be made anything desired. As the tube *A* is made longer, the voltage at *B* must be higher to correspond with it.

One of the fundamental principles of glass blowing is that the soft molten glass must be kept revolving so that it will not fall in on itself, but it is readily seen that it would be impossible to revolve tubes of any great length, especially when constructed in permanent position on the premises to be lighted. But all of these difficulties have been overcome so that a perfect joint between these, comparatively speaking, large-size tubes can be made in a few minutes. Of the many devices worked out by Mr. Moore for this purpose, probably the most important was a radically new form of portable glassblower's gas fire.

The next important problem was how to practically solve the problem of exhausting such large tubes and under such conditions. This also involved much difficult work which finally resulted in a new form of portable high-vacuum mechanical pump driven by an electric motor. The glass vacuum lighting tube is provided at the terminal box with an exhaust nipple to which is attached a rubber hose leading to the vacuum pump placed in any convenient place. After the proper degree of exhaustion has been reached, the nipple is sealed off and the pump is removed. The chemicals from which the distinctive gas within the tube is evolved is placed within the terminals before the exhaust pump is started.

Two salient features of this danger-proof case are, first, keeping the terminals of the high-potential winding entirely within the case in which this high potential is generated; and second, extending from the case simply two plain glass tubes from which no shock can be felt. The case will permit of numerous modifications to accommodate tubes of various lengths from a few inches to hundreds of feet. Such a case or transformer terminal box can be located on the wall of a room and the tube made long enough to extend all the way around the room. Since it is now thoroughly practical to thus build up a tube "in situ," and exhaust it, such a system of illumination has so many advantages, both theoretical and practical, as to make it the culmination of artificial light production. A room thus equipped with a tube in a position, corresponding, say, with the usual picture moulding, the ends of which are brought within an inch or so of each other before they enter the transformer case, is lighted in a manner which fulfills all of the requisites of perfect illumination—a result never before attained.

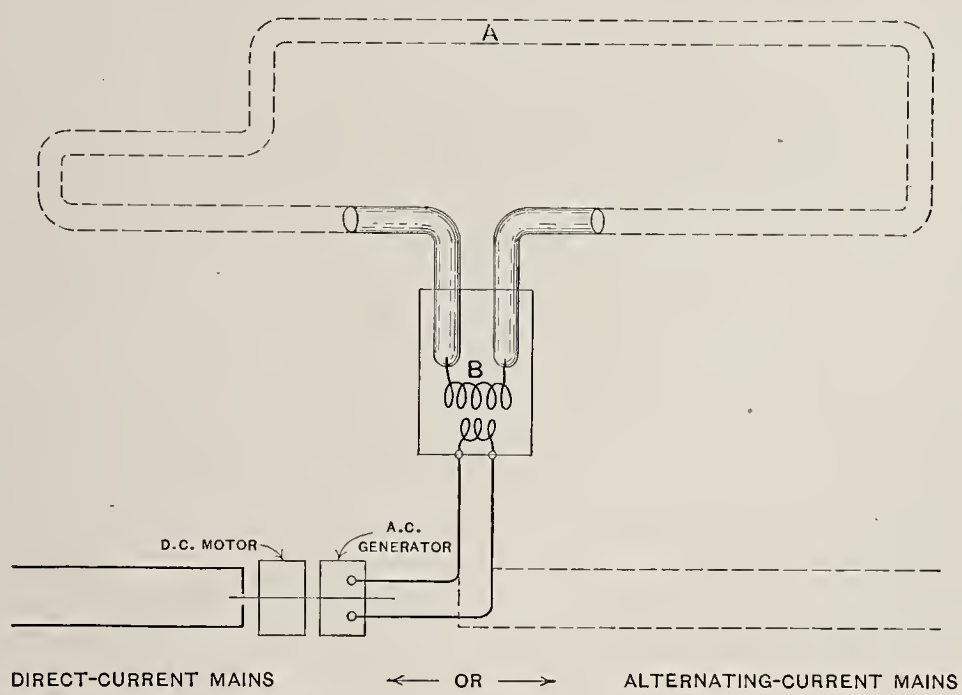


FIG. 2.—THE MOORE METHOD OF GUARDING THE HIGH-POTENTIAL CONNECTIONS

A MOORE "PHOTOGRAPHIC WINDOW"

Mr. Moore has carefully worked out the various devices necessary for practically installing his system, and has proven that the whole scheme of "piping" light, similar to the manner in which gas and water are distributed, is thoroughly practicable. The illumination is perfectly steady and the brilliancy of each square inch of tubing, due to the principles on which the system is based, can be made as great as desired—from nothing to 15 or 20 candle-power per foot of 2-inch tubing. The diffusion of the light is perfect. It illuminates without the glare of the arc or incandescent lamp, and it casts no shadows. Since the end sought is daylight imitation, an ideal light cannot emanate from units or spots but only from many sides, hence the desirability of the continuous tube or its equivalent.

The light radiates from a source scarcely perceptible, because it is placed out of the direct line of vision. If placed on the wall or ceiling it not only dispenses with cumbersome fixtures, but also reduces to a minimum the liability of being broken, which, in any event is not great, as heavy walled glass tubing is surprisingly strong. However, if it should become cracked or broken it can be repaired in a few minutes. Twin tubes also can be installed if desired. In first cost it is cheap, when operated directly by the alternating current from street mains, and therefore without a motor-generator set.

The light's main principle is right. We have here the electric heating of a gas as opposed to the electric heating of a solid. The incandescent lamp has reached its limit in development, while the tube is only starting in its career, and there is every reason to believe that a light of daylight color and diffusiveness will eventually be produced at a cost of one-eighth that of the incandescent lamp.

The light, further, is safe. The high voltage is confined within the transformer case as already explained. The board of fire underwriters approved the claim that it reduces the number of circuit devices, lamps, sockets, key switches, binding posts, flexible cords, fixtures, conduits, fuse blocks, etc., etc., to a minimum. In its final development it will tend to do away with much of the wiring in use to-day.

The term "life" cannot be applied to this system as it is to the incandescent lamp, but rather as it is to the arc lamp, because the tube is installed as a permanent fixture, and when the light becomes dim it requires another "dose" of gas, easily administered, to give it another lease of life. While an incandescent lamp is considered worthless at the end of about 400 hours' service, some of the vacuum tubes on test at the laboratory of the Moore works have run for 1800 hours without showing any signs of diminution.

The tube or tubes can be made of any size, shape or length, from a few inches up to 500 or more feet.

On account of the perfect color values of the Moore light it is used with great success by some of the foremost photographers in New York City, and the results obtained at night or on cloudy days are equal, and in many cases superior, to those obtained in actual daylight. The portrait of the inventor, which is herewith reproduced, was made with a three seconds' exposure at night. The photographic window shown on this page consists of a large, flat, window-like box, $5\frac{1}{2}$ feet long by $4\frac{1}{2}$ feet wide, pivoted at the center of its two sides between two uprights extending from a box-like base mounted on casters. As a whole it actually constitutes a movable skylight, making it of great advantage in getting the light exactly focussed on the subject. Since the window proper is pivoted, it is possible to get as much or as little top light as desired. The light all emanates from one vacuum tube bent back and forth upon itself eight times, these principal lengths being arranged vertically over the entire surface of the front of the window, about 6 inches apart.

The ends of this tube, which has a total length of 43 feet, extend back through the face of the window, which is painted a dull white, and terminate in the electrodes placed in the back of the window. They are in immediate connection with a transformer fed from any alternating source. Since

the tube has a life of at least 1000 hours, it is kept lighted constantly when pictures are to be made, thus doing away with the very objectionable flash-light powders heretofore used. When the tube is operating at about 5 candle-power per foot (about 200 candle-power total) photographs can be taken with an exposure the same as with good daylight conditions, and the power required is about one-fifth as much as that necessary to obtain comparable, though greatly inferior, results by means of arc lamps.

An apparatus similar to this photographic window is also successfully used as an artificial skylight by being fastened to the ceilings of show windows, dark stores, vestibules, etc.

Of course this is a "wireless electric light," and is produced by electric current flowing through a gas confined in the so-called vacuum tube. This tube may be straight, curved or bent in the glassblower's most intricate fashion, and be installed in any position and under any reasonable condition of temperature, in-doors or out. The manufacture of the gas used in the tubes is one of the most important of the many discoveries and inventions made by Mr. Moore. It is a product which is not found in nature and was discovered only after numerous chemical experiments.

The terms "Geissler tube" and "vacuum tube" are understood to be very broad and apply to any form of hermetically sealed enclosure, the pressure within which is less than that of the atmosphere and which is traversed by an electric current. A perfect vacuum, however, has never been attained, and the main distinction between many forms of vacuum tubes is simply in the degree of their exhaustion. For example, it is a comparatively easy matter to exhaust a vacuum tube to such a high degree that it will not give any light. In other words, not enough molecules or atoms remain within it to transmit the electric current.

An ordinary X-ray tube gives practically no light, and one of its most annoying troubles is that its vacuum, on running, actually becomes too high. All light emanating from any vacuum tube is due to the electricity agitating a gaseous residue that is within it.

Although these recent advances of Mr. Moore are radically new, the fundamental principles involved in his system are old. During 1675, a French monk named Picard, while handling a mercury barometer, noticed that the friction of the mercury in the tube caused the latter to glow with a faint light. Thirty years later one Hawksbee took a glass bulb, held his hand against it while it was revolving rapidly, and noticed light within it. Therefore the first "electric light" ever made was a "vacuum tube" light. There was a long line of investigators down to Geissler, whose tubes have been experimented with by almost every country professor, as well as by leading electricians, but have not been improved upon, and are still sold in much the same form as that in which he first made them. They have never been seriously considered as a means of illumination, because they are too small, the quantity of light given by them is almost negligible, they are extremely inefficient, and last, but of greatest importance, they will give their feeble glow for only a few minutes, both because of their mechanical construction and the fact that the residual gases left in them are not any more suitable for electric transmission than a press wire would be as a filament for an incandescent lamp.

By means of improved and new inventions in clamps, methods of heating and other glass-working apparatus, Mr. Moore has developed a new trade, "glass plumbing," making it possible to weld glass tubing with an efficiency equal to that of regular plumbing.

The field of application for the Moore light in photography alone is comprehensive. Not only are the exposures made by a light of constant uniformity in strength and length of time, but artists mix their colors under the artificial daylight, and thus prove its absolute color efficiency, something not approached at all near enough by any other artificial light to allow of this being done. In color photography and photo-engraving the advantages of such perfect color values and constancy of light are many.

Various department stores are now fully realizing the value of artificial daylight in their establishments. For general illumination a straight $1\frac{3}{4}$-inch tube can be installed throughout an entire store, or any part of it, or a photographic window can be introduced in some of the many departments; for example, in the ribbon department for matching colors; in the flower department for the natural daylight effect; in the costly rug and fabric departments and in the art galleries to exhibit the true tints of paintings.

In industrial establishments where the workmen need the best light possible, a continuous diffused white light will be preferable to an incandescent lamp here and there, and in dusty foundries where water will not damage anything, the hose can simply be turned on the vacuum tube when not operating and thus clean off all the accumulated dust and dirt. Being entirely dust and moisture proof, installations of the light can be made in boiler rooms, under water, and, in fact, almost anywhere.

A STUDIO ENTRANCE LIGHTED BY MOORE TUBES

In the lighting of residences many new and heretofore unattainable effects may be produced, and by simply changing the nature of the gas within the tubes, apartments can be bathed in successive shades and colors. A

A CHAPEL EFFECT WITH MOORE TUBES

dining room or conservatory illuminated with the artificial daylight is pleasing beyond description.

It is confidently prophesied that the vacuum tube artificial daylight will be produced at a less cost than any other form of illumination, and in the future buildings will be "piped" for this light as they are now piped for gas and water; and in steamships, ferryboats, railroad trains and trolley cars, in public buildings and on the thoroughfare, long after the sun has set there will be a light that shineth as the light of day.

A new metal, which is similar to aluminium, but still of lesser weight, has been discovered by the French engineer, Albert Nodon, and called "nodium," after him. In color, lustre and structure it is like steel.

THAT every electrical engineer and central station manager ought to be acquainted with the advantages of electrically-driven machines, and should post himself upon the improvements which are frequently being made in this class of vehicles, is the opinion of Howard S. Knowlton, in the New York "Electrical Review." Not only can central station revenue be increased by offering charging facilities, says Mr. Knowlton, but the entire development of electric automobile transportation hangs upon the attitude of central station men toward the furnishing of a suitable current supply to storage battery vehicles at reasonable prices.

General touring of the country is at present impossible with this class of machine, and the reason for this is almost entirely due to the lack of charging facilities.

Central stations exist for the purpose of making money by the sale of current, not only for lighting but for power purposes. It is to-day difficult to find a plant which has no motor load, whether the generators be direct-current or alternating. Out of a mistaken central idea that the lighting load is the only important business for a central lighting station to seek has developed a conservative tendency to leave the power field unexploited—a tendency which has only in recent years been overcome by advances in the design of alternating-current motors and a realization that electrical machinery is most economical when operated at full load.

The owner of a gasoline or steam-driven automobile to-day finds little difficulty in touring the country at will. The grocery store which does not sell gasoline is a rare freak of provincialism; but the central station which charges automobile batteries is one of a sad minority.

It will amount to little if isolated plants and central stations widely scattered from one another in point of distance establish charging stations for automobiles. What is needed is a concerted effort on the part of all central station men to furnish this service. The efforts of the Edison Electric Illuminating Company, of Boston, to establish charging stations in the entire metropolitan district, from Newburyport on the north to South Framingham on the west and Brocton on the south, are largely responsible for the great increase in electric automobiles in Eastern Massachusetts over the number in use only two or three years ago. The town in the United States which has no electric lighting service to-day is very hard to find in any community which has three thousand inhabitants or over.

There are certainly enough central stations to charge automobiles pretty much all through the eastern half of the United States, unless one excepts the prairie States which face the Rockies but do not touch them. Every one of these central stations uses direct current in exciting the fields of its generators, and almost all of this current is of such a voltage that battery charging through a resistance is practicable, if not of the highest economy. In automobiling for pleasure, economy is not at present the main requisite, and there is little doubt that the owners of electric vehicles would be willing to pay a fair profit on the cost of charging their batteries if the mere facilities were provided.

Speed Regulation of Water Power Plants

The Practical Side of the Problem

By ALLAN V. GARRATT

THE art of governing water power plants is still in a formative stage. The theory of the subject is better understood than the practice. The former must necessarily take a mathematical form and is of interest chiefly to those engaged in designing water-wheel governors. The latter is of interest to those who are engaged in the work of designing and building water power plants. This article will deal entirely with the practical side of the question, and will be illustrated by referring to details of plants which have been found satisfactory.

It may be very appropriate to ask first, why is it so difficult to govern the speed of a water-wheel? Why, for example, is it more difficult to hold the speed of a water-wheel constant under variable load than it is to do the same thing with a steam engine? In one respect the conditions of the two things are alike, for we know that when the steam engine or the water-wheel is running at a uniform speed there is an exact balance between the foot-pounds of energy being developed in unit time by the steam passing through the cylinder, or the water in passing through the water-wheel, and the work being done by the engine or water-wheel. The energy and the work are equal and opposite forces, and, consequently, the rate of motion remains the same; or, as a helper around the plant would probably say, the power and load are constant, and, of course, the speed does not change.

Now let us suppose we increase the load suddenly. Take, first, the case of a steam engine. Let us suppose that the load consists of the friction between a brake and the face of a pulley, and we suddenly hang a heavier weight on the brake. If nothing is done to prevent it, the speed of the engine will fall to such a point that the increased friction and the slower speed will be just equal to the less amount of friction and the higher speed, and the engine will again run at a uniform, though slower speed. But the speed will not instantly fall to the lower uniform speed, because all of the rotating parts of the engine and pulley have in them energy of motion which must be expended on the brake before the speed will fall to a uniform slower motion. This will take an interval of time which may be readily calculated.

But now we will suppose that the engine is provided with a good governor. Soon (a small fraction of a second) after the heavier weight is hung on the brake the governor feels the slightly decreasing speed, and at once sets the valve gear to a position which admits enough more steam to take care of the increased load, and the speed almost at once comes back to the normal, having varied but very little from it. A first-class engine governor will set the valve gear to the correct position for new load in less time than it takes the engine to make one stroke, so that the next time the engine takes steam after the load has changed the amount of steam admitted will be just right for the new value of load.

The engine governor is aided in performing its work by a number of things, most prominent among which are the following:— 1st. The valve gear and valves are very light, and their position may be changed with great rapidity. 2. The steam is highly elastic, in a greatly compressed state, and is very mobile, so that, when permitted to do so, it enters the engine cylinder with great velocity, and begins to do its work in an almost inconceivably short space of time. 3d. Steam is very light, and possesses very little inertia in proportion to the dynamic energy it develops, so that its velocity in the pipes and passages between the boiler and cylinder may be instantly changed without changing effective cylinder pressure appreciably.

These factors should be carefully remembered, for unfortunately they are all lacking in the water-wheel, and it is in the skillful attempt to approximate them, or failing in that, to compensate for the lack of them, that the art of water-wheel regulation consists. In passing, it may be said that with an engine of propor proportions, equipped with the best form of governor, it is possible to instantly throw on or off the entire load without increasing or decreasing the speed more than 1 per cent from the normal, the variation lasting not over two seconds. This has never been accomplished with a turbine water-wheel, though it has been approached, and with an impulse or tangential water-wheel it has been nearly realized. We will now look at the obstacles to be overcome in governing water-wheels and the way they have been most successfully surmounted in practice.

Suppose that in place of the steam engine we have a turbine water-wheel doing work by overcoming the friction between a brake and the face of a pulley. If we suddenly hang a heavier weight on the brake, the speed will drop to a new constant value, the same as in the case of the steam engine, only in the case of the water-wheel it will probably arrive at its constant lower speed sooner than the steam engine, for the reason that the rotative parts will probably be lighter and smaller than those of the steam engine, and hence contain less energy of motion or kinetic energy.

But we will now suppose that the water-wheel is supplied with a governor. What will happen? Soon (a small fraction of a second) after the heavier weight is applied to the brake the governor will feel the slightly decreasing speed and will begin to open the water-wheel gate or gates, so as to admit more water. But these gates instead of being light and highly lubricated, like the engine valve, are ponderous affairs, weighing possibly thousands of pounds; they are, perhaps, immersed in gritty water and grind in their seats, and the rigging used to move them is very massive, so as to be able to stand the strain. The water-wheel governor evidently has more of a problem to contend with than had the engine governor. Something must be done for the speed is falling rapidly. The governor takes hold of the gates, and with a mighty effort (perhaps 15 to 20 horse-power for a second or two), moves them rapidly to the correct position for the in-

creased load. But the trouble is not yet at an end. The more widely open gates demand more water; it must approach the water-wheel faster, but unlike the steam, which shot through the pipes and ports with lightning speed to do its work, the water increases its flow deliberately, forced onward by the influence of gravity alone.

If the water-wheel is set in an open flume of ample dimensions the water will gain the proper velocity into the wheel approximately in accordance with the well-known laws for spouting velocity. If, however, the water-wheel is in a closed iron case at the end of a long and more or less horizontal feed pipe, the action will be much slower, for it is evident that if, for example, the amount of water entering the wheel is to be doubled, the velocity of the water in the feed pipe must be doubled, and if the feed pipe is more or less horizontal, the force of gravity does not act on the enclosed water to good advantage, and hence it will gain its new working velocity very slowly.*

In any event, the governor will move the gates to the correct position for new load before the water gets up sufficient velocity to do the increased work, and the tendency will be for the governor to keep on opening the gates until the output of work on the part of the water-wheel equals the load upon it. The position in which the gates would be left would be by far too wide open for the final water velocity, and the speed would, consequently run much too high. The governor would then try to rectify the difficulty by partly closing the gates; but then a new difficulty would develop—as will be described more in detail later on—and the gates would be closed too far. The practical result would be that the governor would move the gates rapidly, first open and then shut, in a futile attempt to stop them at the right place, until finally a balance of forces would be arrived at and the governor and gates would come to a rest. The writer has seen a water-wheel governor make forty-seven unsuccessful attempts to stop the gates at the right place before it finally hit it just right.

Now let us suppose that the speed of the water-wheel has finally become constant under the increased load and we then suddenly lift off a part of the weight on the brake. The governor will soon (in a small fraction of a second) feel the slightly increasing speed and will begin to close the water-wheel gates. It will now experience another difficulty different from that found when the load was suddenly increased. The gates are closed by the governor for the purpose of decreasing the quantity of water which will pass through them in unit time. The water is approaching the water-wheel through a more or less contracted channel, perhaps through a closed pipe of considerable length. It is impossible to slow up this moving water column without doing work upon it. If the channel is open, this expenditure of energy will pile up the water over the wheel slightly—that is, slightly increase the head; if the channel is closed, the expenditure of energy will increase the water pressure at the water-wheel more or less, which is the hydraulic equivalent of increasing the head. This pressure in the closed pipe will be directly as the length of the pipe and the velocity of the water in it, and inversely as the time in which it is slowed down to its new constant velocity. If the above quantities are expressed in feet, feet per second and seconds, and their algebraic sum is multiplied by 0.01324, we shall have approximately the average pressure in pounds per square inch which will be developed at the water-wheel. In any event, as the governor closes the gates the water pressure on them increases and more water will pass through into the water-wheel, making it turn faster than it should. The practical result will be that the governor will want to keep on closing the gates further than it should. But after a time the energy of motion in the water column will be expended, and then the water will be found at its old working pressure and the gates will not be open wide enough. The governor will then want to open the gates on account of the speed falling, and will shoot back and forth a number of times before it stops the gate at the correct position, and the normal speed of the water-wheel will be greatly disturbed.

With high heads and nearly vertical feed pipes the speed will be less disturbed when the load suddenly increases than when it suddenly decreases, and in either case it will be less disturbed than when the head is low and the feed pipe more or less long and horizontal. In the latter case the speed will be less disturbed when load is suddenly decreased than when it is suddeny increased, but in either event will be more disturbed than with high head and nearly vertical feed pipe.

Some readers who are close observers will be inclined to say that the above brief description of the behavior of a water-wheel under variable load does not describe some of the phenomena exactly, and omits all mention of some of the things which take place. But an absolutely accurate description of even the phenomena which have been alluded to would extend this article far beyond permissible limits, and a complete treatment could be attempted only in mathematical form, which would be alike tedious and unnecessary for the purpose of emphasizing the important things to be considered in laying out a plant so as to obtain the best attainable speed regulation.

Enough has been said, however, to point to three things which should have consideration. First, the general design of plant. Second, the design of water-wheel gates and connections between them and the motive part of the governor. Third, the design of the water-wheel governor itself.

GENERAL DESIGN OF PLANT

Experience has shown that unquestionably the easiest plants to govern are those in which the turbines are set in open flumes leading directly from open forebays. The areas of both the flumes and forebays should be of ample proportions, so that the largest and most sudden variations of load will cause little change in level of water over the turbines. It is equally important that tail races be of ample proportions, so that the level of tail water be maintained very nearly constant. Sudden variations in either head water or tail water level are sure to cause difficulties in obtaining speed regulation. Water flowing at a variable rate in open channels often behaves in the most astonishing and annoying fashion, baffling all attempts at calculation, and crooked or badly designed entrances and passages, either in head water or tail water, frequently set up periodic wave motions which cause no end of trouble. All wetted surfaces should have easy, graceful curves, and care taken in this particular will well repay the trouble in good results obtained.

Where the head is comparatively low, practice has shown that there is but little choice, so far as speed regulation is concerned, between wheels set vertically and those set horizontally. Heads below 15 feet usually require vertical setting. Considerations not germane to this article point to the horizontal setting of wheels in open flumes where the natural conformation of the water power permits. Many plants with horizontally set wheels in open flumes have been built in which the design is almost perfect. It would be tedious to enumerate a great number of them, but it may be useful to point to the plat of the St. Anthony Falls Water Power Company, of Minneapolis, Minn., U. S. A.,

* A mathematical treatment of this subject by the author is given in Vol. XVI. Transactions of American Institute of Electrical Engineers, page 361.

and that of the Hudson River Power Transmission Company, at Mechanicsville, N. Y., as models of design for this class of plant from the standpoint of regulation. Many large plants are now being built which are designed on these same general lines, and in such plants it is always safe to predict that great accuracy of regulation will be obtained if the machinery is well adapted to the requirements.

Typical settings of vertical turbines may be found in such plants as that of the Lachine Rapids Hydraulic and Land Company, of Montreal, or that of the Fries Manufacturing Company, of Winston, N. C. Several very large plants are now being constructed on the general lines of the two last named plants, and it is perfectly safe to predict that the speed regulation will be of a high order. All four of the above named plants have been recently elaborately described and illustrated in various technical journals, and hence it seems unnecessary to burden these columns with drawings of them, as they are available to all readers.

Before leaving this portion of the subject it may be permissible to say that an examination of a great many water powers has led the writer to wonder why so many of them have been developed in such a manner as to necessitate the use of long feed pipes, with all their attendant evils, when a little more care in the preliminary design would have resulted, at no greater expense, in water-wheels set in practically open water.

The above referred to element of design has undoubtedly been less considered than any other of equal importance. The facts that you cannot change the velocity of a column of moving water without changing the amount of kinetic energy which it contains, and that the force of gravity acting on water works to its best advantage only vertically, should never be lost sight of. The fact that fluid pressure is the same in all directions is apt to blind one to the importance of the latter statement.

But it is not necessary that the turbines should be set in open water, though that is the best arrangement. As a general statement—and this must be taken as a very general statement— it may be said that if the hydraulic slope from open head water to open tail water is 30 degrees or over, very satisfactory speed regulation may usually be obtained by a careful selection of water-wheels and governors, even with the largest and most sudden load variations. No safe and general rules for a plant of this kind can be laid down. Each individual case must receive a careful examination. The dynamic and kinetic quantities must be carefully calculated and compared with examples of successful practice. The majority of water-power plants belong to this class, and it is unfortunate that the art is not yet sufficiently advanced to reduce the subject to the exactness which would permit of its formularisation for general use.

A number of mathematical theories have been advanced from time to time with so much confidence as to lead a reader to suppose that they had been demonstrated. The writer has not been able to apply any of them successfully to actual practice. It is found in practical hydraulics that one carefully carried out experiment is worth more than many mathematical deductions based on pure theory. The difficulty is to get together all the factors in the equation, some of them being pretty sure to be overlooked.

A long list of plants of this class could be written, in which the most satisfactory speed regulation has been obtained under very severe load conditions. A study of the design of these plants reveals the fact that there is a wide range in the angles of hydraulic slope and in the ratio between the kinetic energy in the enclosed water column and the dynamatic enehgy developed by the water passing through the turbines. But a comparison of carefully tabulated results would show clearly that the greater the hydraulic angle, and the smaller the kinetic energy in the enclosed water are, in proportion to its dynamic output, the more accurate the speed regulation is under similar load conditions. The plants of the Kalamazoo Valley Electric Company, at Allegan, Mich.; of the Concord Land and Water Power Company, at Sewall Falls, N. H.; the United Electric Light Company of Springfield, at Indian Orchard, Mass.; the United Gas and Electric Company, at Berwick, Me.; the Toledo and Maumee Valley Electric Company, and the Niagara Falls Hydraulic Power and Manufacturing Company may be regarded as typical of this class. Each one of these plants is sufficiently different from all the rest to be regarded as typical of a sub-class of its own, though they all come under the general class now being considered. In all of them the degree of speed regu-

FIG. I.—A STANDPIPE AT A WATER-POWER STATION, SHOWING WATER SPILLING OVER THE TOP WHEN THE LOAD AND THE WHEEL GATE OPENING ARE SUDDENLY DECREASED

lation which has been obtained is eminently satisfactory.

But there is still another class of plants which is the most difficult of all, and the resources of the engineer are taxed to the utmost to produce satisfactory regulation in them, though such efforts are frequently crowned with success. This class of plants consists of those where the water-wheels are situated hundreds or thousands of feet from open water, and where the water is brought to the water-wheels in practically horizontal pipes. If in such plants a large portion of the head be developed in draught tubes below the water-wheels, the case becomes serious indeed. Frequently, as was referred to earlier in this paper, developments of this kind are entirely unnecessary, and an inspection of the lay of the ground would lead one to the opinion that some one who had a hand in making the design had an interest in selling the pipe line. Sometimes, however, there is no other possible development and the water power, if developed at all, must be developed through long pipes.

In these plants the water-wheel governor alone, no matter how perfect its design and construction, cannot produce satisfactory speed regulation. Fortunately there are two things which can help the governor out. One is the standpipe; the other, the relief valve. Both of these must be especially designed for the particular conditions under which they are to be used. In some cases the standpipe is of the most use; in others, the relief valve. Occasionally both are required. This matter may be best illustrated by referring to a few specific cases, which will be selected as illustrating widely different, yet typical, natural conditions.

Suppose it is found necessary to bring the water either in a long, horizontal pipe, with its upper end practically at open water level, or in a contracted open channel to the water-wheel located at a considerable distance from the dam. In this case the standpipe, in the ordinary acceptance of the term, is of no use. Starting with a small standpipe, gradually increasing its area, would show by experiment that the larger you make it up to a certain point, the better would be the regulation. It would finally become a large open tank in which the water-wheel would be preferably set, or if that were not feasible, the tank would be placed at the water-wheel end of the flume and connected to the wheel case by a very short pipe of ample area.

There has been sufficient practice with this sort of plant to permit of the requisite dimensions of the open tank being predetermined with accuracy. Such a plant as has been described above is that of the Driggs-Seabury Gun and Ammunition Company, of Derby, Conn., U. S. A. This plant, as originally designed, was ungovernable, as was pointed out by the writer before it was built. Subsequently placing an open tank of suitable proportions directly behind the wheel case made it possible to obtain very accurate speed regulation under very sudden and large load variations.

Now suppose a case much similar to the last above named, but in which the natural conditions necessitate setting the water-wheels up nearly to open water level, a large proportion of the head being developed in long draught tubes beneath the water-wheels. If these water-wheels were set in an open tank, as in the previous case, the water would be very shallow over them. If also the natural conditions or the design of building prohibited the use of a tank of sufficiently large area, it would be found that upon the governor suddenly opening the gates to take care of a sudden load, the water would be sucked down through the draught tubes, lowering the water level over the wheels sufficiently to admit air into them. This would immediately pass into the draught tubes, breaking the water seal in them and emptying them of water, and the speed of the water-wheels would fall greatly below normal until the water in the long, closed, horizontal feed pipe accelerated sufficiently under the influence of gravity to again fill the turubines and draught tubes and drive out the air.

In this case we should have recourse to a different device. The turbines would be placed in a closed iron flume, connected directly to the end of the long feed pipe. No standpipe nor open tank would be used, but on top of the feed pipe directly behind the water-wheel case, would be placed a very large flapper valve, so arranged that it could open outward, but not inward. Upon load, and consequently the water-wheel gate orifice, being suddenly decreased, the flapper valve would open like an old-fashioned skylight on hinges, and the water, which otherwise would increase pressure on the water-wheels, would escape. Upon load, and consequently water-wheel gate orifice, suddenly increasing, the pull or the draught tubes would shut the flapper valve down water-tight on its seat, so that no air could enter, and the entire pull of the draught tube would become effective in accelerating the water velocity in the long, horizontal feed pipe, which consequently would acquire its increased working velocity in a small fraction of the time otherwise required. Experience has taught the proper area and design of the flapper valve. A plant such as that just described is that of the United Gas and Electric Company, of Dover, N. H., at South Berwick, Me., in which a satisfactory speed regulation is obtained in spite of the very unfavorable conditions encountered.

Now suppose a case in which the pipe line is very long and the head quite high. In such a case it is, of course, impossible to use the devices heretofore named, and a properly designed standpipe will here aid a good water-wheel governor in producing good speed regulation. The cross section of the standpipe is obtained by taking into consideration the length of time necessary for the force of gravity to increase the velocity of the water in the flume from its minimum to its maximum working value, and then making the cross section of the standpipe such that during that interval of time the water level in the standpipe will not fall sufficiently to lower the effective head on the water-wheels below the point which can be taken care of by the governor without lowering the rotative speed of the water-wheel below the permissible limits.

The height of the standpipe should be but little greater than the hydrostatic head—that is, when the water-wheels are at a rest and the water is not moving in the flume, the level of the water in the standpipe should be very near its top. This will, of course, result in water spilling over the top of the standpipe whenever load, and consequently gate orifice, is suddenly decreased. This spilling of water, though inconvenient, is necessary; for if the standpipe is made sufficiently high to prevent the water spilling over the top, it is evident, that, at times, the pressure on the water-wheels will be at least that due to the artificial head which results when the water is forced up into the standpipe.

A plant such as here described is that of the Albany & Hudson Railway and Power Company, at Stuyvesant Falls, N. Y. Fig. 1, on the preceding page, shows a standpipe in the above plant. The photograph was taken a moment after a large load had been instantly removed. The energy which is being gradually expended for several seconds in lifting the water out of the top of the standpipe would otherwise have been expended in a much shorter time on the water entering the water-wheels, and in the latter case would have resulted in an increase of speed beyond the power of the governor to control; whereas, with the standpipe as shown, the gov-

ernor is able to hold the speed within permissible limits.

It was stated above that the spilling of water out of the top of the standpipe was necessary. There is one very effective way of preventing it. A relief valve having a venting area equal to that of the water-wheels may be placed at the base of the standpipe. It is hydraulically balanced, so that it will open under a very small increase of pressure, say 1 pound per square inch more than the static pressure of the standpipe. When the water-wheel gates are suddenly closed the relief valve will open and permit the escape of water which would otherwise be spilled out of the top of the standpipe. When the water-wheel gates are suddenly opened the balanced relief valve does not come into operation at all, and the water column in the standpipe gets in its work on the water-wheels, while the nearly horizontal water column in the feed pipe is getting up to its new working velocity.

Many engineers who have experimented with relief valves condemn them for the very practical reason found in their experience that they will neither open nor close when they should. This, however, is due to the faulty design of the valve. Recent practice has shown conclusively that relief valves may be balanced so accurately as to be perfectly water-tight when not in action, and yet will open wide upon flume pressure rising to a fraction of 1 pound per square inch above normal. Several relief valves in practical operation are of such large size that they have a venting orifice of 415 square inches, and in operation vent 148 cubic feet of water per second when they are wide open. The proper design of relief valves is a large subject, and the limitations of this article will not permit of its elaboration. The obvious advantage of venting the water through the relief valve rather than out of the top of the standpipe is in the case of disposing of the discharge water and the non-accumulation of ice in winter.

In some cases it is found that the ratio between the rate of acceleration of water in the feed pipe and the possible demand of water by the water-wheels is such that the governor can take care of loads going on suddenly, but that the kinetic energy in the water in the feed pipe will raise the flume pressure beyond the safety limit upon the gates being closed suddenly and the ratio between the kinetic energy in the water in the feed pipe and the dynamic energy developed in the water-wheels is beyond the ability of the governor to control the speed. In such cases the standpipe may be dispensed with and the relief valve alone may be used. The plant of the Great Northern Paper Company, at Millinocket, Me., is arranged in this way.

In this plant there is a feeder 1100 feet long and 11 feet in diameter. At the lower end of it there are three pairs of horizontal turbines driving electric generators and also two small turbines driving exciters. Each of the generator units is provided with a suitable governor, and at the extreme end of the flume there is an hydraulically balanced relief valve having a circular discharge orifice 23 inches in diameter. This valve is so delicately balanced that the increase of flume pressure, due to suddenly closing part way the gate of one of the little exciter turbines, will cause it to open for a moment and vent a little water. Its maximum venting capacity is sufficient to take care of the largest load variations which can possibly occur without letting the flume pressure rise more than a few pounds above normal. When we realize that the water column in this flume weighs 6,520,800 pounds, and that when at working speed it contains 2,226,000 foot pounds of momentum energy, or 4119 horse-power seconds, which must be expended somewhere before the water column may be stopped, it will be seen that the relief valve is not an unimportant part of the plant, and that its failure for one second to do its duty would result in bursting the flume.

The above named plant is also very interesting as an illustration of a water power which could be developed in no other way than by the use of very long, closed, steel flumes. There are five of these leading to the plant—the one described above and four others 10 feet in diameter, which at this time are being equipped in a manner similar to that of the first. Properly speaking, there is no natural water power in the ordinary use of that term at this plant, and an inspection of the country prior to its construction would not have revealed to the unpracticed eye any evidence to the effect that water power could be developed at that point. A few years ago no one would have dreamed of constructing a water power plant under such apparently unfavorable conditions. Its construction even now required a large amount of courage on the part of those furnishing the capital, and engineering of a high order on the part of those who planned the construction. The ability to control and regulate so large a weight of water under so high a head and possessing so large an amount of kinetic energy in proportion to the dynamic energy it develops, is a practical object lesson which will undoubtedly bear fruit in the development and use of many water powers which are not now supposed to exist. In this plant the speed regulation is of so high an order that it is no exaggeration to say that there is no industry requiring power, no matter how large and sudden the load variations might be, which could not be successfully carried on in a plant of similar design.

FIG. 2.—A DIFFICULT PROBLEM IN GOVERNING

Occasionally a water power of this general class is found in which the conditions are so unfavorable as to almost baffle the most carefully executed attempts to produce very fine speed regulation under large and sudden load changes. Fig. 2, on this page, shows one of the most difficult

plants to govern in the United States. The closed flume has several bends in it as it goes up the hill, at the crest of which is a standpipe. From this point the closed flume is comparatively level up to open water, which is

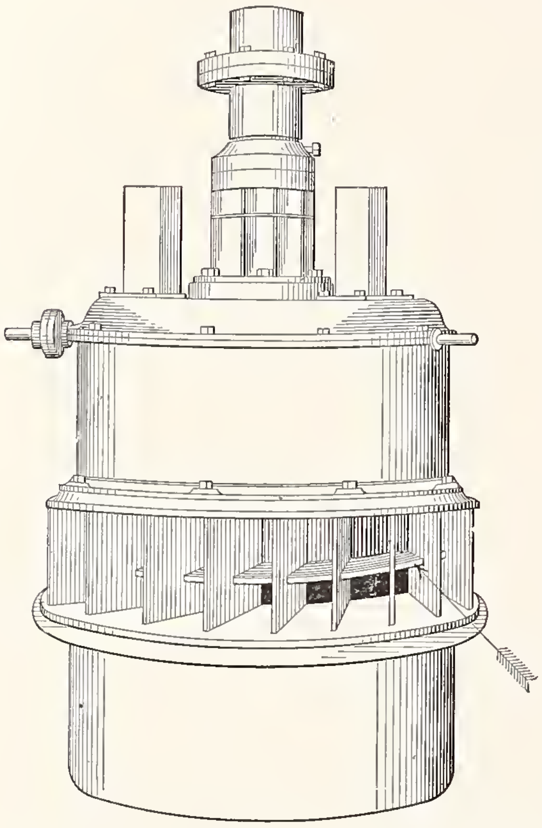


FIG. 3.—A CYLINDER GATE WITH FINGERS REACHING BETWEEN THE GUIDES

1500 feet away and 146 feet above the power house. The use of first-class governors, especially designed for the purpose, has made this plant capable of regulation under small load variations, but under very large and sudden load variations the speed cannot be kept within permissible limits at present. Much experimenting with relief valves has been done in this plant, but up to the present writing with only partially satisfactory results. It is believed, however, that sufficient data have been obtained to solve even this difficult problem, and that some changes which will be made when warm weather permits will render it possible to throw off and on large loads instantly without materially disturbing the speed.

From the wide range of plants which have been referred to it will appear that there is almost no natural condition under which water powers are found which cannot be developed so as to produce an operative plant. The broad lesson to be learned is, that the nearer we can approach to having our mechanical unit consist of a water-wheel or wheels placed in an open flume of ample proportions, the better will be the speed regulation, all other things being equal; and the further we go away from this simple design the more difficult becomes the problem, the more complex becomes the devices necessary to obtain satisfactory speed regulation, and consequently the greater will be the expense.

DESIGN OF WATER-WHEEL GATES

A book of fair size might easily be written on this subject, and it is difficult to treat it briefly. The two things important above all others are—first, make the gates work easily; and, second, connect them in the simplest possible manner to the actuating part of the governor. So far as obtaining good speed regulation is concerned, experience has shown that equally good results may be obtained with either wicket, cylinder or register gates. The last named gate is so rarely used at present that it will not here be considered.

Wicket gates of many designs have been used, and practice has shown that it is hopeless to attempt to obtain good speed regulation if the wickets are pivoted at one end, so that, as they open and close, they move like a door upon its hinges. These gates cannot be water-balanced. They sustain full flume pressure upon their outer surfaces, and when it is necessary for the governor to open them in perhaps a second or two, something is sure to break. If they were constructed heavy enough to stand the strain, the connections and the governors also would have to be of such ponderous proportions as to carry the cost far above permissible limits. Makers of such gates usually provide worm gears to open them, and they are wise in so doing. They could also open them with a jack-screw, and it would be found to be about as useful as the worm gear, if speed regulation is the end sought.

It is impossible for a governor to start from a rest and twirl a worm gear through twenty or thirty turns in a second or two and stop it at the right place. Even if it did succeed in stopping it at an approximately correct position, the momentum in the rapidly moving parts, when suddenly brought to rest, would break something. If a water-wheel gate requires a worm gear or a train of multiplying gears to open it, the wisest thing to do is to get another water-wheel. The writer knows of not a single case where good speed regulation under variable load has been obtained where such devices are used. This statement may be disputed by some.

There are, however, wicket gates which are pivoted at the middle. These gates, if properly designed, are nearly in water-balance in all positions and they lend themselves most readily to the requirements of good speed regulation. A very good example of gates of this kind may be pointed out in the plant of the Niagara Falls Hydraulic Power and Manufacturing Company, at Niagara Falls. These gates are moved by pinions on their axes, worked by an internally cut gear which is rotated by means of a link and an eccentric placed on the shaft leading to the governor. This shaft turns but 120 degrees to completely open the gates. The gates are of a high order of design, and experience with them has fully demonstrated their utility. Notwithstanding the fact that they are subjected to the full pressure of Niagara Falls, they move with surprising ease at all stages of their opening. Gates of very similar design, but differently rigged, have been successfully used under very low heads. The spectacle of a wicket-gate turbine working under 5 feet of head and driving an electric railway load at a practically uniform speed, is almost as inspiring a sight as that of a similar turbine driving a similar load under the full head of Niagara Falls.

Cylinder gates, if of proper design, are very well adapted to obtaining good speed regulation. The one thing necessary is that they be plain cylinders. Of late years some manufacturers have placed upon their cylinder gates fingers or lips reaching out between the guides, and by so doing have rendered their water-wheels very nearly ungovernable. A cylinder gate so built has the general shape of a top hat with notches cut out of the brim. Fig. 3 shows such a gate in position inside of the guides; the arrow points to one of the fingers, which in various makes of turbines are of different forms. Fig. 4 shows fingers recently

FIG. 4.—FINGERS CUT FROM CYLINDER GATES

cut from cylinder gates. The one to the left shows its lower side or the surface over which the water is supposed to pass in entering the turbine; as a matter of fact, the water touches but very little of this surface. The one to the right shows the upper surface, against which the water presses in its endeavor to enter the turbine. These

fingers were taken from different makes of turbines, but in each case the hypothenuse of the triangle is the line of juncture between the cylinder and the finger. The one to the right shows the line of fracture plainly. Now let us examine into the effect of such fingers upon the question of speed regulation. These fingers stand directly in the path of the water as it approaches the turbine, and consequently the water presses against them and tends to close the gate violently.

The finger to the left in Fig. 4 was one of twenty-four cut from a single cylinder gate. Each of these fingers presented a surface of 9.69 square inches, or all of them a total of 232.3 square inches, in the path of the moving water. It was found by experiment that after the fingers were removed from the gate 4972 pounds less counterbalance was required to balance the gate, or in other words, the water pressed down on each finger $4972 \div 232.3 = 21.4$ pounds per square inch. Theoretically, the pressure should have been equal to a head of twice that due to the water velocity. In the above case experiment showed that the pressure was equal to about three times the head due to the velocity, the discrepancy between the theoretical and measured values being chiefly due to the fact that the water did not approach the fingers perpendicularly, and the dead water between the fingers and the cylinder presented a larger area of pressure.

The practical side of the matter may be stated as follows:—It was desired to operate the turbine at a very constant speed under large and sudden load variations. A well-designed governor, capable of developing 10,000 foot pounds of energy in two seconds, was attached to this gate, but it was found impossible to govern the turbine. The very heavy counterweight which was necessary to balance the gate, of course, possessed inertia. It was found impossible to start and stop it quickly enough. When the counterweight, or part of it, was removed, the strain on the gate rigging and governor was so great that gear teeth were constantly stripping or shafts twisting off. Finally the twenty-four fingers were all removed from the gate by the gentle persuasion of a hammer and cold chisel. At once all difficulty in moving the gate disappeared. The counterbalance, being no longer necessary, was removed, and the governor was able to produce a very accurate speed regulation under large and instantaneous load changes. The turbine, deprived of the fingers, has been, and is now, in continuous operation to the entire satisfaction of the owner.

The manufacturer claimed that by removing the fingers the efficiency of the turbine was lowered; perhaps so, but carefully conducted tests before and after the fingers were removed, showed that at all stages of gate, from one-quarter open to full open, just the same amount of power was developed with or without the fingers. Undoubtedly a little less water passed through the turbine before the fingers were removed than afterwards, but the difference was slight.

If there is any one thing which injures the susceptible feelings of water-wheel builders and rubs their fur the wrong way it is to talk in actual figures about the efficiency of their wheels. The writer has considerable data on this subject of the increase of efficiency obtained by the use of fingers on cylinder gates, but it is of a purely confidential nature and may not be published. The gist of the whole matter is that the very small amount of efficiency gained by the use of fingers is no compensation for the constant annoyance and expense which their use inevitably causes.

It should be kept in mind that whatever gain in efficiency is obtained by the use of fingers on cylinder gates depends upon the shape of the turbine. If the inlets between the guides are comparatively wide and shallow, the use of fingers adds little or nothing to their efficiency, though they render the turbine ungovernable. Take for example, the turbines in the Millinocket plant of the Great Northern Paper Company previously mentioned. These turbines have wide, shallow inlets and plain cylinder gates without fingers, yet they showed in the testing flume an efficiency of 85.9 per cent, at full gate, and an average efficiency of 83 per cent at from three-quarters to full gate. This is certainly not a bad performance and they govern remarkably well. On the other hand, if the inlets between the guides are narrow and deep, the use of fingers on the gates is of some use at part-gate. The purchasing public is more to blame in this matter than the water-wheel builders. The size of a turbine is usually designated by the purchaser in terms of diameter. If, for example, one make of 42-inch turbine is rated by its maker as developing more horse-power than another make of turbine of the same diameter, the purchaser is apt to choose the turbine which develops the most power, though it does not follow that by so doing he is getting more for his money. Also, the turbine maker is constantly urged by the purchaser to give a high rotative speed under low head. This also leads to a design of turbine which tempts the maker to use fingers on the gates. So many questions come into consideration in the selection of a turbine for any particular set of requirements that it is impossible to elaborate the subject within the limitations of this article. A better understanding of the subject by the purchasing public, and a willingness on their part to co-operate with turbine builders, will undoubtedly, in the end, do away entirely with the practice of putting fingers on cylinder gates.

Fingers on cylinder gates have been treated at length for the reason that they are the cause of more annoyance and more poor speed regulation than any other structural detail. It is gratifying to note that some water-wheel builders have entirely abandoned the use of fingers on their gates, and that others who have not quite reached that point are making strong efforts with their customers to induce them to have the fingers left off their gates. It is safe to say that at this time at least three-quarters of the cylinder-gate turbines under contract or being installed in plants where speed regulation is a desideratum, are fitted with plain cylindrical gates without fingers.

DESIGN OF WATER-WHEEL GATE CONNECTIONS

This subject may be conveniently divided into two parts. First, the immersed connections, or those which begin at the gate and terminate in a shaft or shafts protruding from the water; and, second, those which begin where the former leave off and terminate at the governor.

As to the former, there are but two successful ways of connecting wicket gates, one being that already described as in use in the plant of the Niagara Falls Hydraulic Power and Manufacturing Company. Such connections are usually of bronze, and, if well designed and built, give uniformly good satisfaction. This design is more often employed under high heads. A more usual method is to connect the outer ends of the wickets through links tangentially to a circular member which is rotated around the turbine axis by means of a lever terminating in a gear sector which engages a pinion on the shaft protruding from the water. This is a very common practice, and where the parts are of fair design and construction it gives very satisfactory results. Scores of thousands of horse-power of wicket gate turbines, rigged in this manner, are in operation and are giving admirable results. Connections of this kind necessarily have a good many small moving parts, and builders in the past have perhaps erred in making them too light for the requirements of mod-

ern speed regulation. They should be strong and rigid in construction and all pivotal parts carefully fitted. It may seem absurd, but the writer has seen within two years the radial arms connecting the wickets to the banjo of a turbine sold for use in an electric power plant, connected by means of cariage bolts. It is perhaps unnecessary to add that it did not take long for these gates to come to an untimely end. It is, however, gratifying to note that some makers are now building wicket gate connections in a very thorough and substantial manner.

Cylinder gates as now built, are almost universally moved by means of two draw-bars terminating in racks which engage pinions on a shaft perpendicular to the turbine axis. Until quite recently these racks have been immersed, and the pinion shafts have been connected through bevel gears to a shaft parallel with the main shaft and protruding from the water. This method is open to the objection of having gear teeth under water, subject to corrosion and obstruction by bits of wood floating in the water. At present some builders are bringing the draw-bars out of flume heads through stuffing-boxes, and placing the racks and gears in the air. The objection to this is the difficulty which water-wheel builders seem to experience in getting the pitch line of their gears on the axis of thrust. This appears to be merely a question of design, and will undoubtedly be overcome. The writer is inclined to the opinion that, all things considered, the method last described is preferable, though it must be admitted that in some of the largest and most successfully operated plants, as, for example, that of the St. Anthony Falls Water Power Company, previously alluded to, the racks and gears are immersed.

Probably it is near the truth to say that either method will give good results from the standpoint of speed regulation if care be exercised in the design and finish of moving parts. Builders, as a rule, have erred in making connections of this kind too heavy. The general idea seems to have been to get in as much material as possible, in the hope of making things strong. This is an error. These connections have to be started, stopped and perhaps reversed in motion in very short spaces of time, and practice has shown that massive gate connections have frequently failed from their own inertia in places where they were later replaced by lighter but better designed parts, which gave good results.

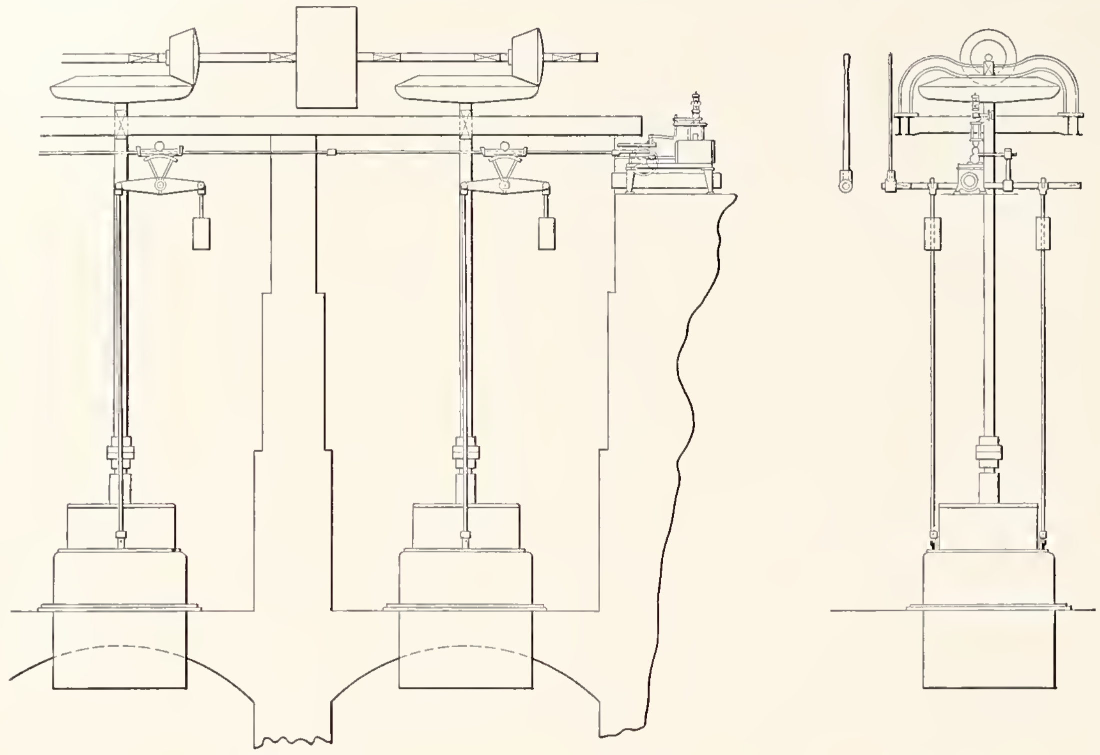


FIG. 5.—A GOOD METHOD OF CONNECTING THE GATES OF SEVERAL VERTICAL TURBINES

The writer has found that cut gears of four, or occasionally three, diametral pitch and $2\frac{1}{2}$-inch face are heavy enough for rigging in air, and also for most immersed gears if made of bronze. Occasionally immersed gears of three, or even two, diametral pitch may be necessary, but such cases are rare. The above statements are not in accordance with the usual practice of water-wheel builders, but the advisability of using gears of the proportions above named has been demonstrated in hundreds of cases. Sometimes the form of the gear teeth is so bad as to render the entire rigging incapable of prompt and certain operation. There is, of course, no excuse for this.

The rigging between that usually furnished by the water-wheel builder and the governor is very difficult to treat in a general way for the reason that the location of the governor is usually fixed by the space available for it and the location of surrounding objects.

In connecting up several hundred governors it has been found that rarely can the same connections be used. Experience has been the only teacher in this matter, and that which has been learned has been chiefly those structural details which should be avoided. In plants of low head where the electrical units are large, it is frequently found necessary to actuate the gates of several vertical wheels working as one mechanical unit by means of one governor. Several ways of rigging such wheels have been tried. The common method has been to place two racks on the top of each gate. These engage a pair of pinions on a horizontal shaft directly over the turbines and perpendicular to its axis. The end of this shaft carries a bevel gear engaging another on the bottom of a vertical shaft. The tops of these four vertical shafts are then all connected to one general shaft placed horizontally parallel with the line shaft, and directly below the crown gears. To this shaft the governor is attached.

This method has never given satisfactory results. For four turbines thirty-two gears would be required. The gear friction is so great that the whole system is sluggish and fails to respond quickly enough to permit of good speed regulation. But by far the greatest difficulty experienced with such a rig is in the twist which takes place in the long, horizontal gate shaft whenever the governor moves. This causes the gates nearest the governor to move first and those further away to come along with great deliberation. The result of this is that the gates nearest the governor are invariably carried too far, and when the more remote gates come up to correct position the average gate opening is too great or too small, as the case may be, and the governor has to make another move. This action would be kept up unceasingly. It was found by experiment that to obviate this difficulty the long, horizontal gate shaft would have to be of prohibitively large diameter.

A more recent and better design is to connect the upper ends of all the vertical draw-rods to radial arms on a long, horizontal shaft placed as before, parallel with the line shaft and below the crown gears. Opposite to each radial arm, connected to a draw-rod, was placed another radial arm carrying at its end a weight equal to that of the weight of the gate. This method eliminated all gears except one rack and gear connecting the general gate shaft to the governor. The only diffi-

culty with this design was that it was still subject to the twist in the long shaft. However, turbines may be successfully governed in this way. In one plant sixty turbines, in ten units of six each, each unit having one governor, are in successful operation, the speed regulation being very satisfactory.

But the most successful method of connecting up such gates is shown in Fig. 5. It will be noticed that each pair of draw-rods is connected to a pair of walking beams, which carry counterweights on their opposite ends. Each walking beam carries a gear sector which engages a rack on a long, horizontal reciprocating member terminating at the governor. The racks on the reciprocating member are "sleeved" on it and held in place by pins, which may be removed if it is desired to disconnect any turbine from the governor.

By this method any one or any combination of turbines may be handled by the governor or any turbines by hand, at will, by means of a lever shown in the end projection. It will also be noted that there are no twisting strains in the long shaft, the only strains being those of extension and compression, which may easily be provided for. The design is being used in two large and important plants now being built.

Fig. 6 shows one good method of connecting a governor to a pair of horizontal wicket-gate turbines. It will be noted that the shaft connecting the two gear sectors on the gate stems goes directly to the governor and is connected to it through a pin clutch which may be opened and a hand-wheel on the governor may then be used to move the gates by hand. The only improvement on this design which can be suggested would be to eliminate the countershaft between the governor pulleys and the turbine shaft by placing the governor beyond the draught-tube quarter turn, so that the governor pulleys might belt directly on to the turbine shaft. The limitations of available space prevented the location of the governor in this manner on the drawing which shows the design used for three units in a modern power plant.

Frequently the only possible location of the governor prevents anything like direct connection between it and the turbines. In such cases experience has shown that it is wisest to avoid the use of several pairs of bevel gears and long shafts, and in their place use a steel rope drive. This method has great flexibility and permits of governor locations which would otherwise be impossible. Fig. 7 shows a design of this kind. The governor is located in the only available space in the whole building and yet its connection to the turbines is perfectly adequate. The steel rope used is small in size, made of very small wire especially laid up, and its ends are fixed to the grooved sheaves, which are provided with internal take-ups, so that the rope may be kept tight as a fiddle string. This general are simplicity and directness. These two things should never for a moment be lost sight of, and the more completely they are embodied in the design, the better will be the speed regulation. To these two may be added another, and that is freedom from lost motion. These three things are absolutely necessary if successful results are to be expected. The slightest mo-

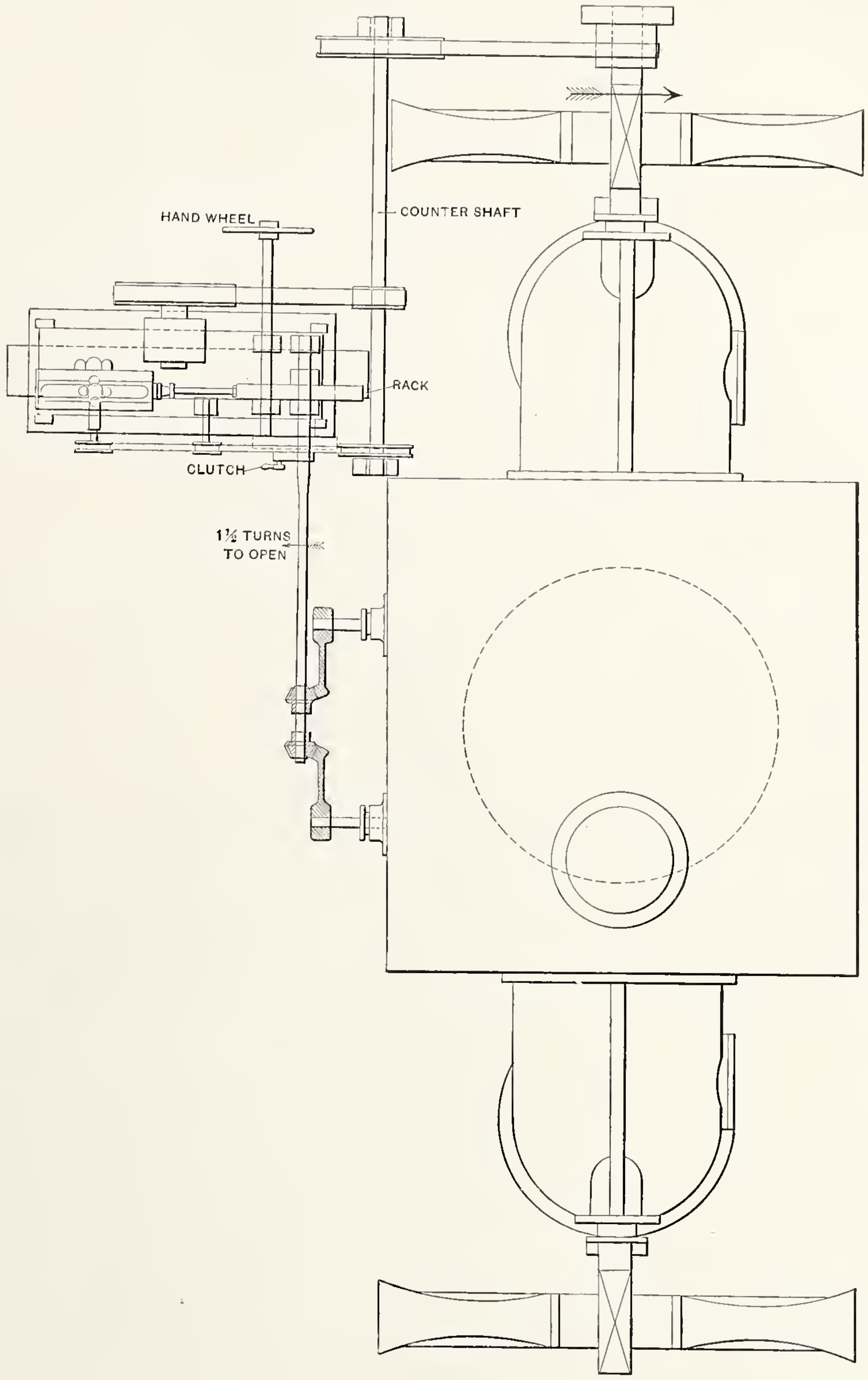


FIG. 6.—GOOD PRACTICE IN CONNECTING A GOVERNOR TO A PAIR OF HORIZONTAL WICKET-GATE TURBINES

method of connection is in successful use in many plants where the requirements for speed regulation are most exacting.

Examples of different methods of connecting governors to turbines might be multiplied almost indefinitely, each illustrating features of interest. In the few which have been shown it will be evident that the two ends which have governed the design

tion of the governor must be transmitted in the simplest and most direct manner and in the shortest possible interval of time to the turbine gates.

WATER-WHEEL GOVERNORS

From the considerations which have been advanced it will be seen that even under the most favorable conditions, the water-wheel governor has a difficult duty to perform, while under the

unfavorable conditions frequently found, it is called upon to do more things in a shorter space of time than often falls to the lot of a machine. We are confronted at the start with the proposition that the governor is supposed to hold the speed of the turbine constant, but that it does not begin to perform its work until after the speed of the turbine has begun to change; hence, an absolutely perfect speed regulation can never be obtained with a governor which depends upon centrifugal force in rotating balls or weights. All governors which have come into practical use are of this general type. Even after the governor has moved the gate the water tends to enter them at a higher or lower velocity than normal; the governor must therefore be able to think. It must know enough to stop the gates short of or carry them beyond the position indicated by the change in position of the centrifugal balls. It must be able to do this no matter how large and sudden the load change or how sluggish the water column may be, or how large its momentum energy may be in proportion to the dynamic energy it will develop in the turbine. To accomplish this has been the aim of inventors ever since the use of electric power created a demand for constant speed, and roused other users of water power to the advantage to be derived from good speed regulation.

The governor must be able to start from rest, move the ponderous gates of the turbine to the correct position in a very short space of time and come to rest as promptly as it started. A good governor should be able to move the turbine gate to its correct position in one or two seconds upon large load changes taking place, and in a correspondingly shorter interval of time for small load changes. It should be of such design that several turbines, working as independent mechanical units, may drive electric generators run in parallel without their tending to unequally divide the load. It should also be capable of varying the speed of the turbine so as to be able to get two or more alternators in phase and step. Likewise it should be capable of regulating the speed of a turbine connected either mechanically or electrically with a steam engine, so as not to unequally divide the load nor disturb the steam engine. It should be of such design that in event of the belt between the governor balls and the turbine shaft breaking or being thrown off by a malicious person, the governor will quietly close the gates and bring the plant to rest instead of letting it run away.

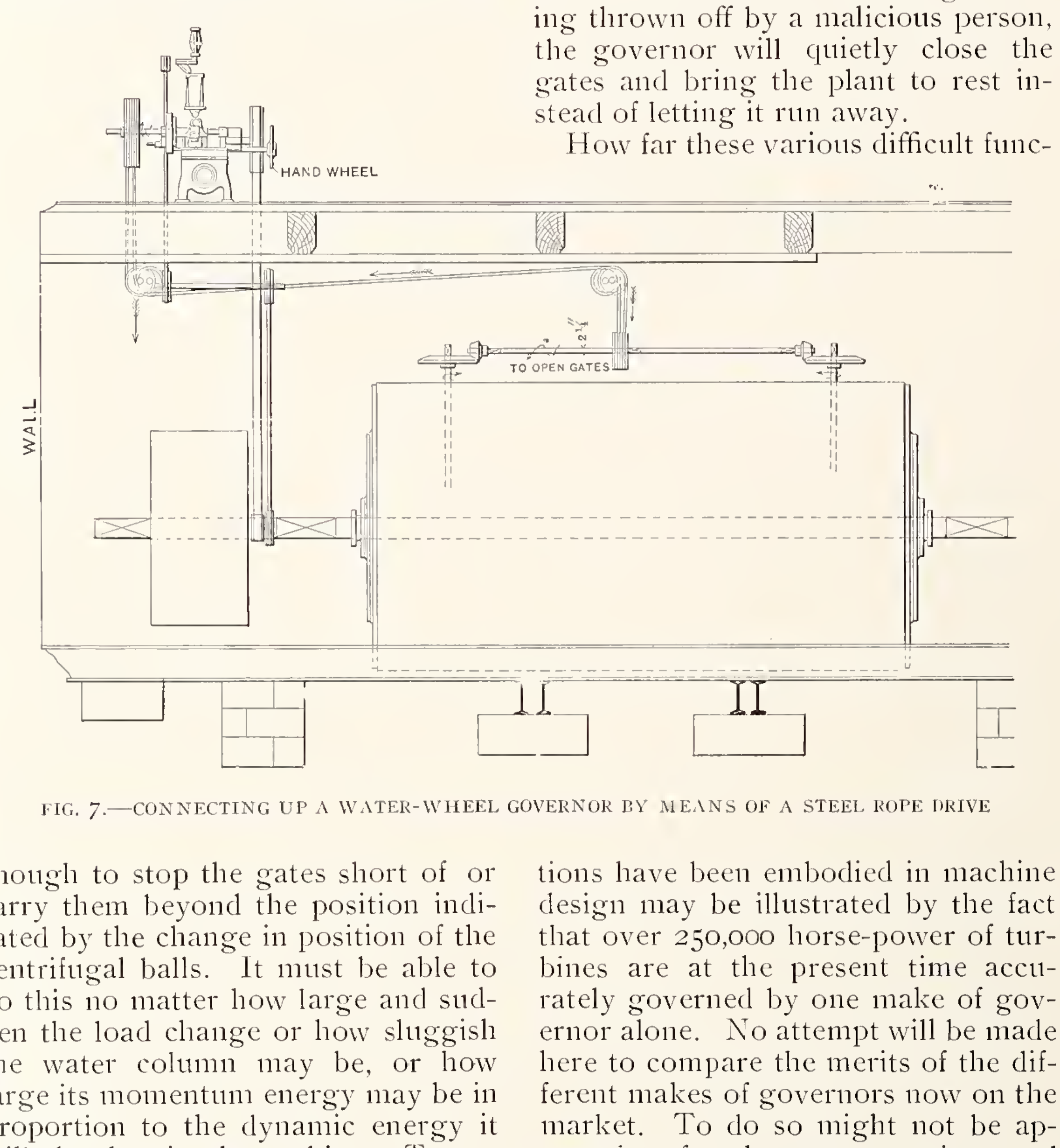


FIG. 7.—CONNECTING UP A WATER-WHEEL GOVERNOR BY MEANS OF A STEEL ROPE DRIVE

How far these various difficult functions have been embodied in machine design may be illustrated by the fact that over 250,000 horse-power of turbines are at the present time accurately governed by one make of governor alone. No attempt will be made here to compare the merits of the different makes of governors now on the market. To do so might not be appropriate for the present writer, and the intricacies of design are such that the attempt could not be but tedious. Neither will it be attempted to review historically the development of water-wheel governors from their first crude form to their present high stage of dedevelopment at the present time. Nor will it be attempted to discuss nor criticise the curious theories of governing and more curious mathematics of the subject which have appeared from time to time. The few simple facts which have been presented have been taken entirely from the experience of actual practice, and everything which belongs to the hoped for achievement of the future has been rigidly excluded.

In conclusion, it may not be amiss to say that experience has abundantly proved that if care be taken in a proper selection of turbines, governors and auxiliary appliances, and if thought be given to the design of the steel and masonry which conduct the water from the pond or open forebay through the turbines to the tail-race, few, if any, water powers are of such natural conformation that they may not be developed into plants which will satisfy the most exactinig requirements for speed regulation.

The governing of plants in which tangential or impulse water-wheels are used is an interesting subject, pregnant with much recent practical experience. The writer regrets that the length of this article, which has already exceeded proper limits, prevents its being here discussed.

Cost of Water Power in France

According to recent figures given in the "Scientific American," the cost of water-power development in France varies from $21.40 to $150 per H. P., depending on the head to be dealt with, the lowest expenditure being upon a fall of 140 meters in Haute-Savoie, the horse-power being calculated at the turbine shaft. At Geneva, for the first group of turbines erected, of 840 H. P., and for the river works then completed, the capital cost amounted to $300 per effective horse-power. The groups of turbines subsequently erected cost but $95 per horse-power, and the completed works would cost but $135 per horse-power. At the chlorate works at Valorbe, the capital expenditure upon the development of 3000 H. P. amounted to only $19.45 per horse-power. At Niagara the rates charged to ordinary consumers by the Cataract Power and Conduit Company varied from 2 cents per unit for 1000 units per month or less to 0.64 cent per unit for 80,000 to 200,000 units per month. The cost of energy for power purposes from water-power stations in France and Switzerland varied from 2.1 cents per unit for small powers to 1.24 cents per unit for large powers.

In some of the sleeping cars of the Chicago, Milwaukee & St. Paul Railroad, passengers may now have electric lights in the upper berths. The sockets are fixed in the berths, but for the lamp the passenger must apply to the porter.

The Development of Electric Power Transmission

By LEWIS BUCKLEY STILLWELL

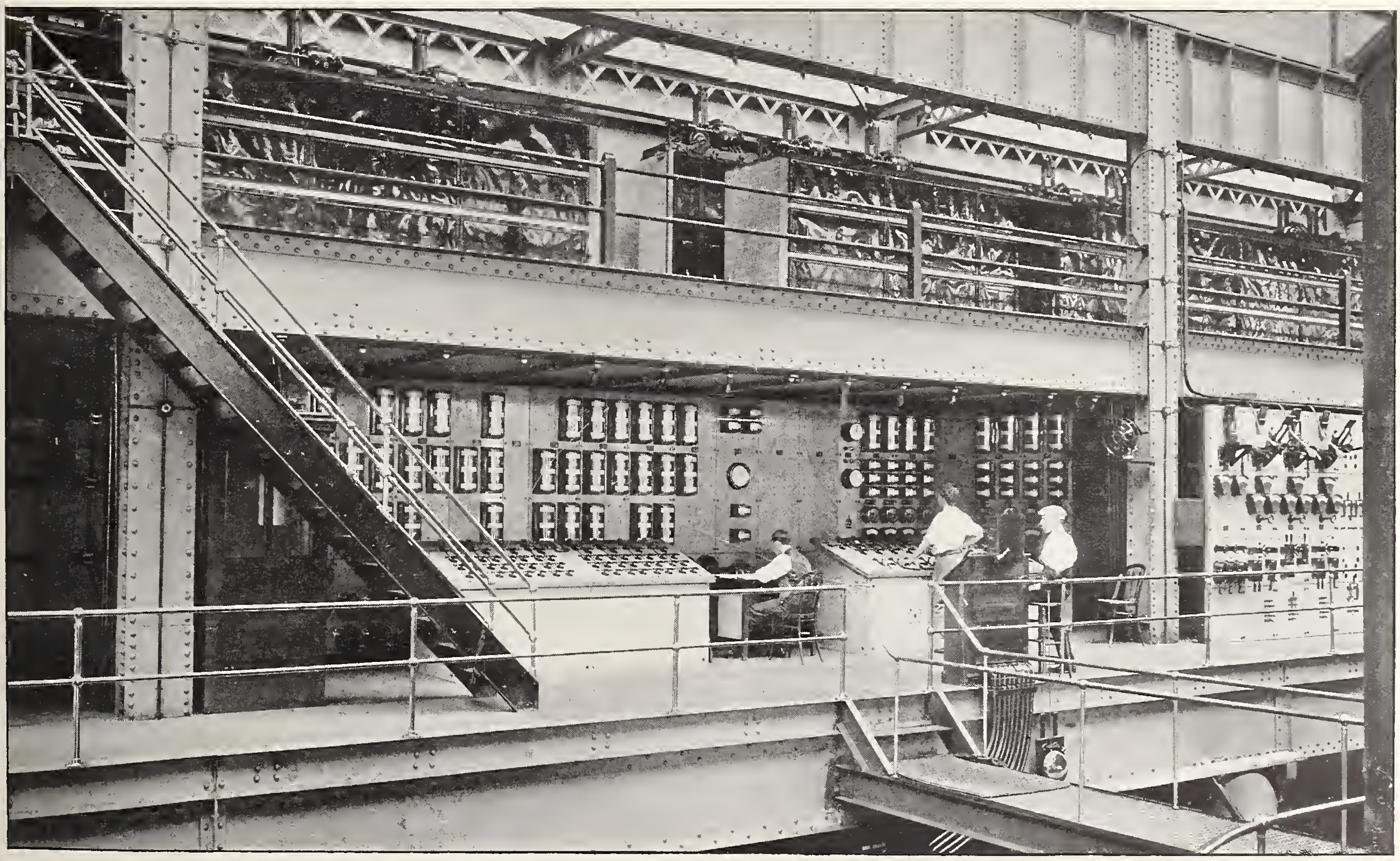
Through the courtesy of "Cassier's Magazine" it has been made possible to reproduce here the following article by Mr. Stillwell, from advance sheets of the forthcoming Electric Power Number of that publication. It seems needless to commend it to attention. Mr. Stillwell is so well known as one of the foremost men in the electrical profession, and has been so prominently identified with the history of electric power transmission, that the reader is assured at once of having before him the best that can be said on the subject.—The Editor.

IN October, 1886, in a small room on the top floor of an old house in Pittsburg, Pa., three hundred incandescent lamps were lighted continuously for a period of about two weeks by alternating current transmitted a distance slightly exceeding two miles, over a single-phase circuit, comprising two copper wires of No. 4 B. & S. gauge. The potential used was 1,000 volts, the frequency about 130 cycles per second, and the lamps were connected in parallel to the secondary circuits of half a dozen transformers. The ratio of transformation was 1,000 to 50.

This was the first instance, in America at least, in which alternating current was used in transmitting electric energy beyond laboratory distances for the supply of translating devices connected in multiple arc. The alternator used to supply the power was driven by a belt from a line shaft, to which a high-speed automatic engine was connected, and this generating plant was located in a shop of the Westinghouse Electric & Manufacturing Company on the banks of the Allegheny River within a mile of the site of old Fort Duquesne.

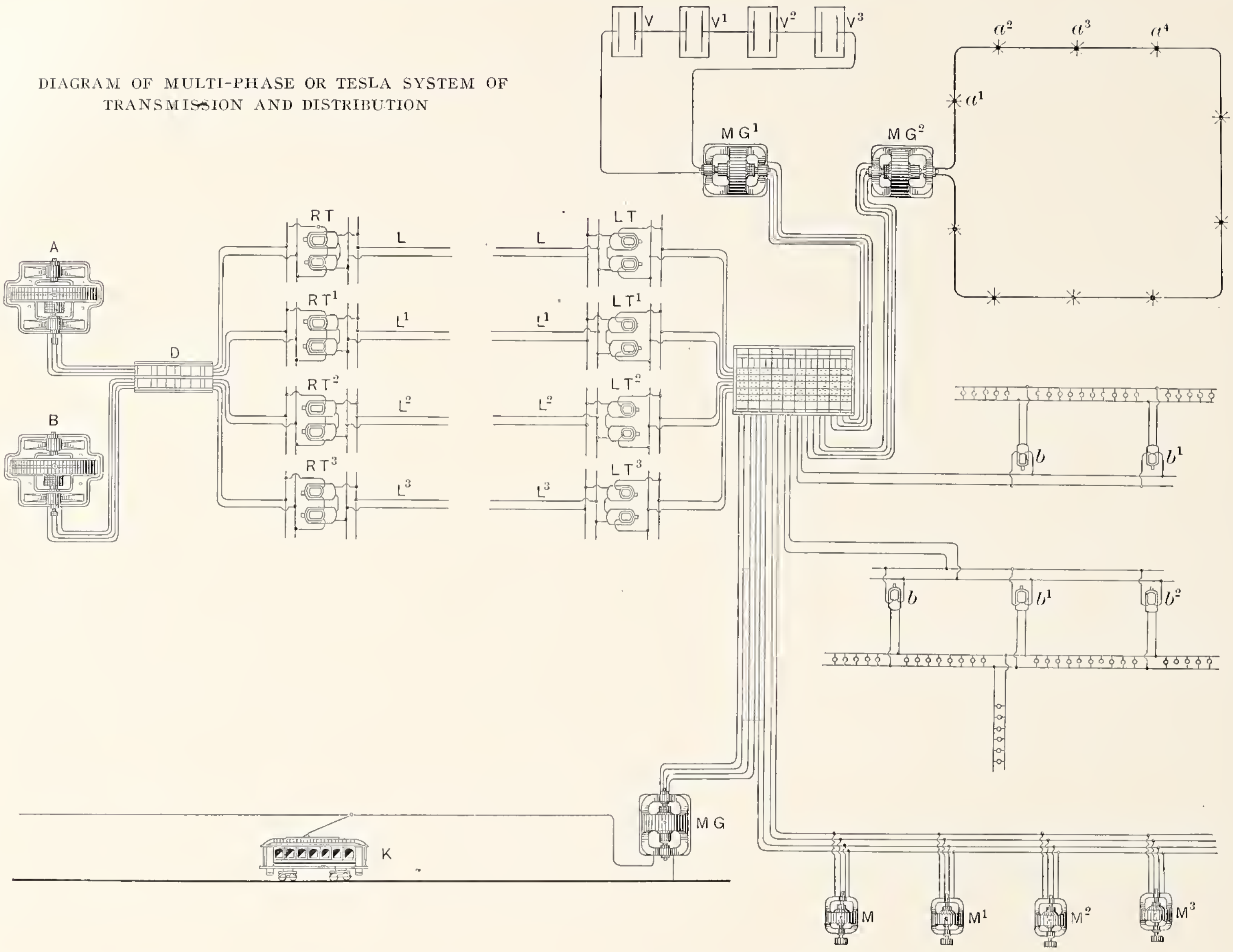
It was the writer's fortune to be detailed to watch those lamps during twelve hours out of every twenty-four during the test,—his first practical experience in applied electricity,—and he vividly recalls the keen interest with which everybody who had anything to do with the work observed the results. In the history of American industrial progress the Lawrenceville test, as it has been called, was an event of no little importance. To Stanley and Shallenberger, for the technical skill and for the patient work which produced the apparatus, and to George Westinghouse, whose far-sighted enterprise realized possibilities at that time scouted by others, all those who are now deriving benefit from the wonderfully extended use of alternating currents are under an obligation which they should be glad to recognize.

Prior to the Lawrenceville test, distribution of electric energy to lamps or motors had been accomplished by continuous-current systems operating at potentials of 110 to 220 volts. The three-wire system invented by Edi-



OPERATING AND INSTRUMENT BOARD OF THE MANHATTAN RAILWAY COMPANY, NEW YORK

DIAGRAM OF MULTI-PHASE OR TESLA SYSTEM OF TRANSMISSION AND DISTRIBUTION



son, permitting the use of a potential of 220 volts, was coming into use for general purposes in the larger cities, and was regarded as the highest potential available for such work. The general significance of the results of the Lawrenceville test was keenly realized; but the difficulties encountered in attempting to devolop single-phase, alternating-current motors, capable of operation at the high frequency then used, practically prevented for a number of years the use of alternating current for power purposes. It was, however, rapidly developed and extensively applied in the field of incandescent lighting.

Tesla patented the polyphase alternating-current motor in 1888, but this also was slow in development, owing largely to the fact that for a long time in America efforts were principally directed toward the development of a motor adapted to the high frequency of 130 cycles per second. In 1890 the Westinghouse Company adopted as standards two lower frequencies,—60 cycles per second and 30 cycles per second. The step facilitated greatly the development of satisfactory polyphase motors, and not long afterward they began to come into commercial use.

The commercial significance of the Lawrenceville test is strikingly illustrated—although the impression conveyed by the illustration is a somewhat exaggerated one—by the story of the manager of a gold mine in Colorado, who, in 1896, was able to operate a stamp mill located at a distance of about three miles from his water-power by alternating current transmitted to the motor over a circuit consisting of iron telephone wire of ordinary size. This was accomplished by using a high-potential single-phase alternating current. The cost of the telephone wire was about sixty dollars. It is stated that an estimate for a continuous-current plant to do the same work had been submitted by a manufacturer of continuous-current machinery, and that these plans called for the installation of copper

TABLE I.—AMERICAN CENTRAL ELECTRIC STATIONS IN 1902

Items	Total	Private Stations	Municipal Stations
Number of stations	3,620	2,805	815
Cost of construction and equipment	$504,740,352	$482,719,879	$22,020,473
Earnings from operation	84,186 605	77,349,749	*6,836,856
Income from all other sources	1,514,000	1,385,751	128,249
Gross income	85,700,605	78,735,500	6,965,105
Total expenses	68,081.375	68,835,388	5,245,987
Salaried officials and clerks—			
Average number	6,996	6,046	950
Salaries	$5,663,580	$5,206,199	$457,381
Wage-earners—			
Average number	23,330	20,863	2,467
Wages	$14,983,112	$13,560,771	$1,422,341
Power plant equipment—			
Steam engines—			
Number	5 930	4,870	1,060
Horse-power	1,379,941	1,232,923	147,018
Water-wheels—			
Number	1,300	1,308	82
Horse-power	438,472	427,254	11,218
Generating plant equipment—			
Dynamos—			
Direct current, constant voltage—			
Number	3,823	3,405	418
Horse-power	442,446	418,913	23,533
Direct current, constant amperage—			
Number	3,539	2,957	582
Horse-power	195,531	157,768	37,763
Alternating and polyphase current—			
Number	5,122	4,300	822
Horse-power	987,003	896,315	90,688
Output of stations—			
Kilowatt hours, total for year	2,453,502,652	2,257,598,213	195,906,439
Total number of arc lamps	385,698	334,903	50,795
Total number of incandescent lamps	18,194,044	15,616,593	1,577,451

* Includes estimated income from public service.

circuits costing more than sixty thousand dollars.

United States Census Bulletin No. 5, recently issued, places us for the first time in possession of many important and extremely interesting statistical facts relating to the use of electricity for light and power purposes in the United States exclusive of its use for traction purposes. Table I. of this bulletin cannot be improved by further condensation, and is, therefore, here reproduced.

It will be noted that of the aggregate output of dynamos installed in central stations which supply power exclusively for lighting and power purposes, which aggregate amounts to 1,624,480 horse-power, the rated output of alternating-current dynamos constitutes more than 60 per cent. A considerable number of electric power plants, installed primarily for the purpose of operating street and electric railways, also supply current for lighting and power purposes, and if these be added to those which furnish power for lighting and power purposes only, the grand aggregate of central stations becomes 3,738, the number of arc lamps 419,561, the number of incandescent lamps 19,636,729, and the total income from the sale of the current $90,458,420.

The relative commercial importance of the central electric station industry and gas industry is shown in Table II., which also is reproduced from Census Bulletin No. 5.

The peculiar value of alternating-current development resulting from the reduction in cost of distribution which is effected by this class of apparatus is illustrated by the fact that 75 per cent. of the central electric stations are in towns of less than 5,000 inhabitants, as compared with 22.8 per cent. of the gas plants.

As regards stationary motors, the aggregate number installed is 101,064, and their aggregate horse-power amounts to 624,686. The total rated horse-power of steam engines and water-wheels used to drive dynamos is 1,772,813, of which total 77.8 per cent. are the indicated capacity of steam engines and 22.2 per cent. the stated capacity of water-wheels.

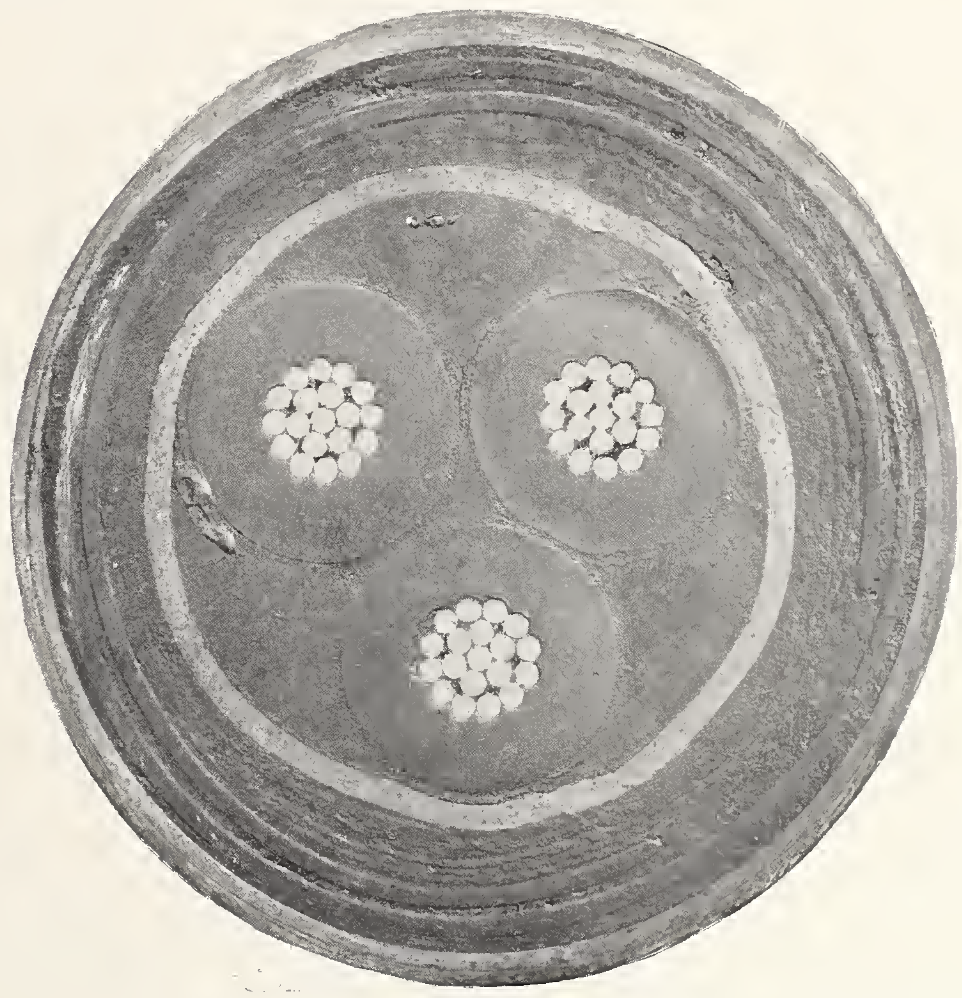
The relative number of dynamos and relative aggregate horse-power of alternators, as compared with direct-current, constant voltage machines and direct-current, constant amperage machines, are shown in Table III.

It will be noted that the average alternator is a much larger machine than the average direct-current machine of either of the two direct-current classes.

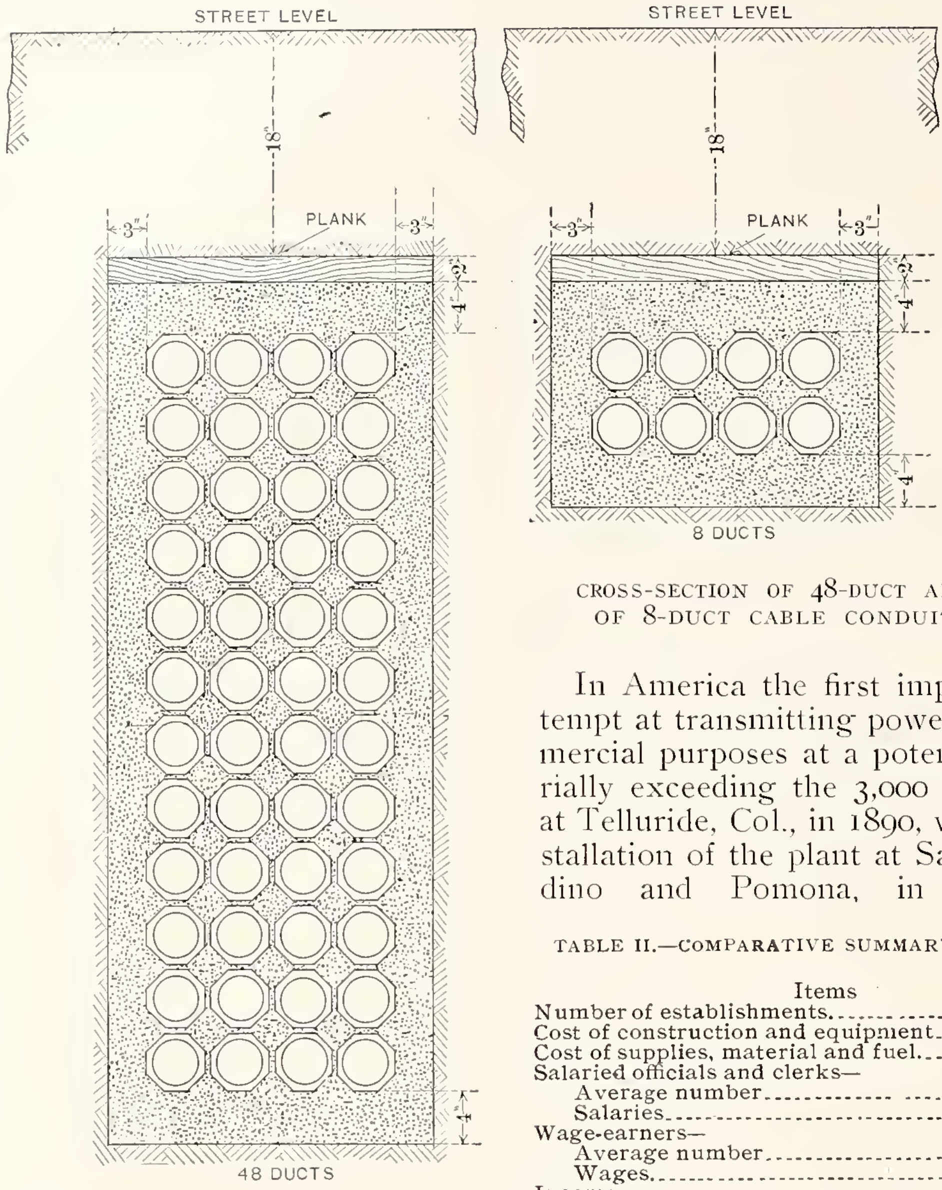
It is impracticable within the limits of this article to attempt anything like a comprehensive review of the development of alternating-current apparatus for transmission and distribution of power which shall refer even briefly to the many small steps which, in the aggregate, have contributed so much to the march of progress; but in brief retrospect reference to a few of the more important steps may serve to emphasize the remarkable rapidity which has characterized the evolution of this comparatively young, but very vigorous, addition to present industrial assets.

In 1890 the celebrated Frankfort-

A FULL-SIZE SECTION OF THREE-CONDUCTOR, PAPER-INSULATED CABLE FOR 11,000 VOLT THREE-PHASE TRANSMISSION USED BY THE INTERBOROUGH RAPID TRANSIT CO., NEW YORK



FULL SIZE RUBBER-INSULATED, STEEL-ARMORED, THREE-CONDUCTOR CABLE FOR SUBMARINE WORK, USED BY THE INTERBOROUGH RAPID TRANSIT COMPANY OF NEW YORK, UNDERNEATH HARLEM RIVER



CROSS-SECTION OF 48-DUCT AND OF 8-DUCT CABLE CONDUITS

Lauffen transmission illustrated and emphasized the possibilities of high-potential alternating current in bridging great distances. The potential used during the test was at times 14,000 volts, and at other times 28,000 volts; the distance was 110 miles; the amount of power was small,—about 200 H. P. The transmission was in no sense a commercial success, nor, indeed, was it expected to be. It served its purpose, however, of demonstrating, upon a scale sufficiently large, the possibility of insulating a long circuit effectively for potentials very high as compared with anything previously attempted, and it also served the purpose of concentrating attention in many quarters upon the subject of electric power transmission, and so contributed in a striking and effective manner to the commercial development of a relatively new art.

TABLE III.—PERCENTAGES THAT THE NUMBER AND HORSE-POWER GF THE DIFFERENT VARIETIES OF DYNAMOS ARE OF THE TOTAL STATIONS IN 1902

Kind of Dynamo	Total
Total—	
Number	100.0
Horse-power	100.0
Direct current, constant voltage—	
Number	30.6
Horse-power	27 2
Direct current, constant amperage—	
Number	28.3
Horse-power	12.0
Alternating and polyphase current—	
Number	41 0
Horse-power	60.8

In America the first important attempt at transmitting power for commercial purposes at a potential materially exceeding the 3,000 volts used at Telluride, Col., in 1890, was the installation of the plant at San Bernardino and Pomona, in Southern California. The potential used was 10,000 volts; the distance from the water-power to San Bernardino was 29 miles.

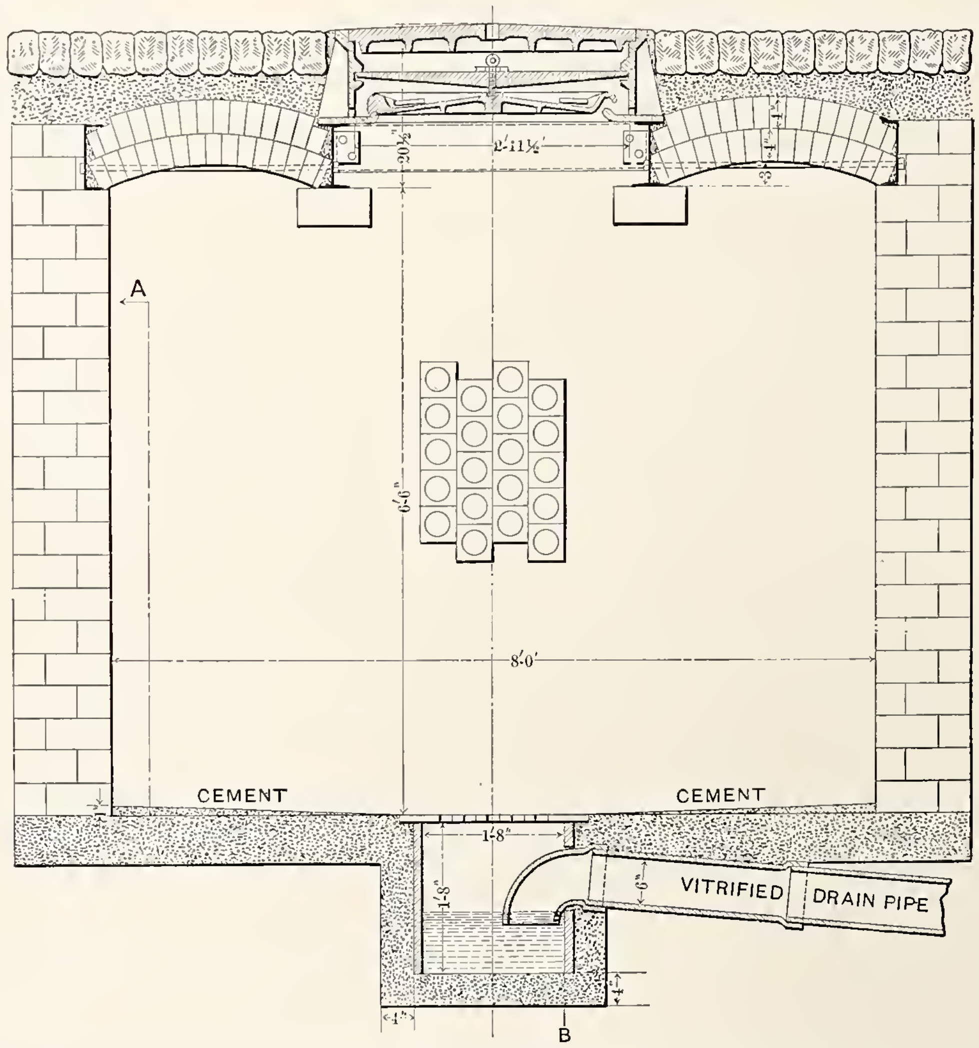
On May 2, 1893, Mr. George H. Winslow, engineer in charge of the plant, connected the Pomona circuit in series with that to San Bernardino and transmitted about 100 E. H. P. to San Bernardino, a distance of $42\frac{1}{2}$ miles, this being by far the greatest distance attained in America up to that time.

About that time, in various shops and laboratories of America and Europe, the polyphase motor was fast taking commercial form, and at the Chicago Exposition of 1893 some striking and important exhibits of polyphase apparatus were shown in operation. Among these was a complete power transmission plant, comprising a 375 K. W., two-phase alternator, an outfit of step-up and step-down transformers connected by a high-potential circuit, a 375 K. W. rotary converter delivering continu-

TABLE II.—COMPARATIVE SUMMARY OF AMERICAN CENTRAL ELECTRIC STATIONS AND GAS PLANTS

Items	Central Electric Stations, 1902	Gas Plants, 1900
Number of establishments	3,620	877
Cost of construction and equipment	$504,740.352	*$567,000.506
Cost of supplies, material and fuel	22,915.932	$20,605,356
Salaried officials and clerks—		
Average number	6,996	5,904
Salaries	$5,663,580	$5,273,500
Wage-earners—		
Average number	23,330	22,459
Wages	$15,983,112	$12,436,296
Income	85,700,605	† 75,716,693

* Capital. † Value of products.

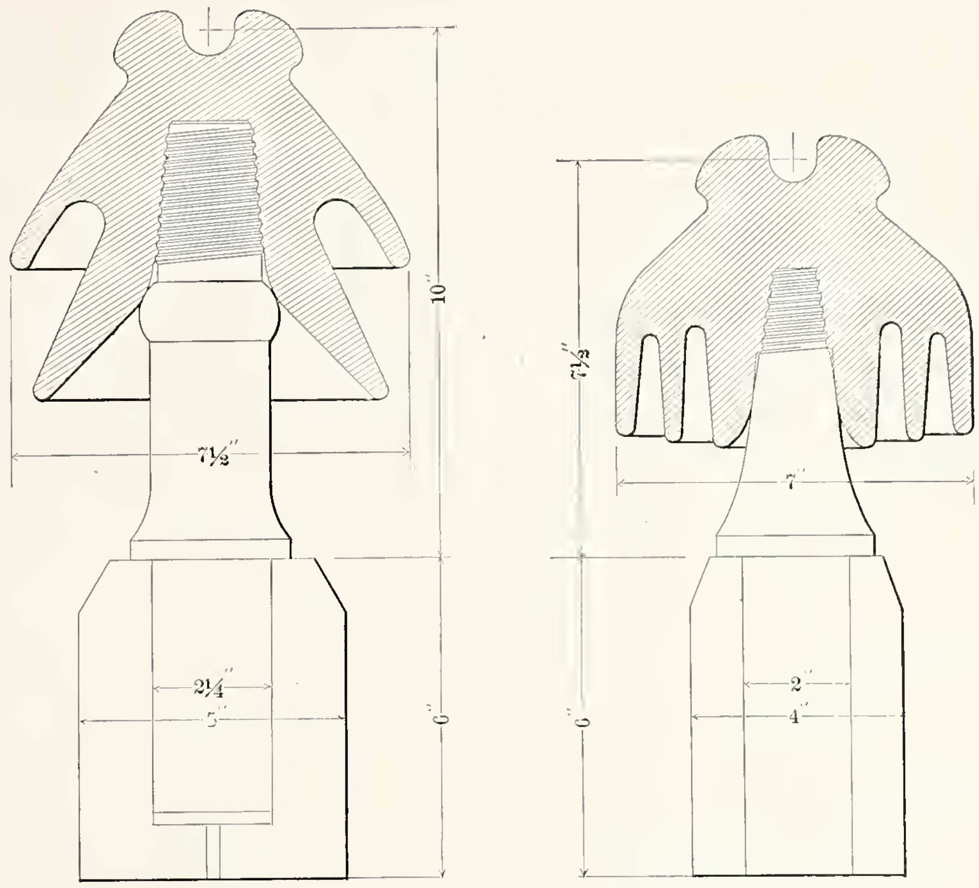


CROSS SECTION OF A CABLE MANHOLE OF THE MANHATTAN DIVISION OF THE INTERBOROUGH RAPID TRANSIT COMPANY, OF NEW YORK

ous current at 550 volts, a 60 H. P. synchronous motor, and a number of induction motors, ranging from 1 H. P. to 15 H. P. The system was two-phase, the frequency 30 cycles per second, and the potential of the transmission circuit 10,000 volts. At the receiving end of the line incandescent lamps were supplied through transformers, and arc lamps were fed by continuous current from the rotary converter. Continuous current from the rotary converter was also used to operate direct-current motors. The diagram on page 282, which is reproduced from a descriptive circular published at the time, shows that this plant embodied all essential features of the latest transmission plants, except that two-phase circuits were employed instead of the three-phase plan now generally preferred. The Germans were first to perceive clearly the advantages of the three-phase system, as compared with the two-phase system, and to push the development of three-phase apparatus. Dobrovolski showed me, in Berlin, in 1890,—possibly as early as 1889,—a three-phase motor probably cabable of developing a quarter of a horse-power. In America, Bell, of the General Electric Company, installed the first three-phase plant at Redlands, in California, in 1893.

From the autumn of 1892, to October, 1893, the officers and engineers of the Cataract Construction Company were systematically working toward a decision of the great engineering question of the best method of utilizing the power of Niagara, and in the month last mentioned they executed a contract for polyphase alternating-current machinery to be installed in a central station and utilized in generating electricity to be distributed for power and lighting purposes. The decision of the Cataract Company, which had studied the subject exhaustively, both in Europe and America, had a notably stimulating effect, and less than two years later, in the Niagara power number of "Cassier's Magazine," issued in July, 1895, the late S. Dana Greene, in a very interesting article upon "Distribution of Niagara Energy," was able to list not less than seventy electric transmission plants in America in operation or under construction.

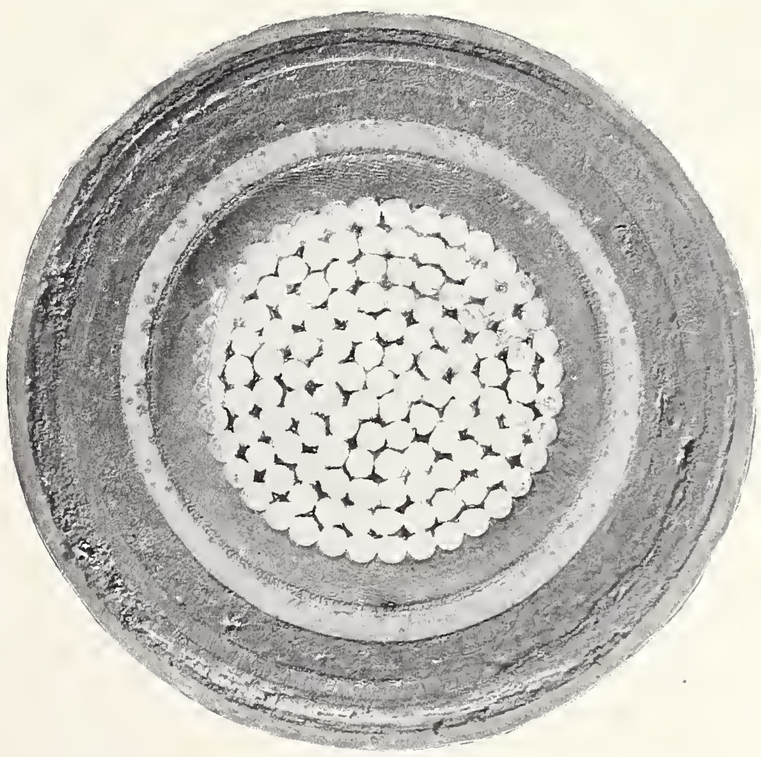
To my mind, the most important events in connection with the evolution of electric transmission in America are (1) the Lawrenceville test of 1886, by which the commercial practicability of the constant-potential transformer,—the key to high-potential transmission,—was demonstrated; (2) the invention of the polyphase motor, patented by Nikola Tesla in 1888; and (3) the adoption, in 1893, of the polyphase alternating-current, constant-potential system as the means of distributing power from Niagara Falls.

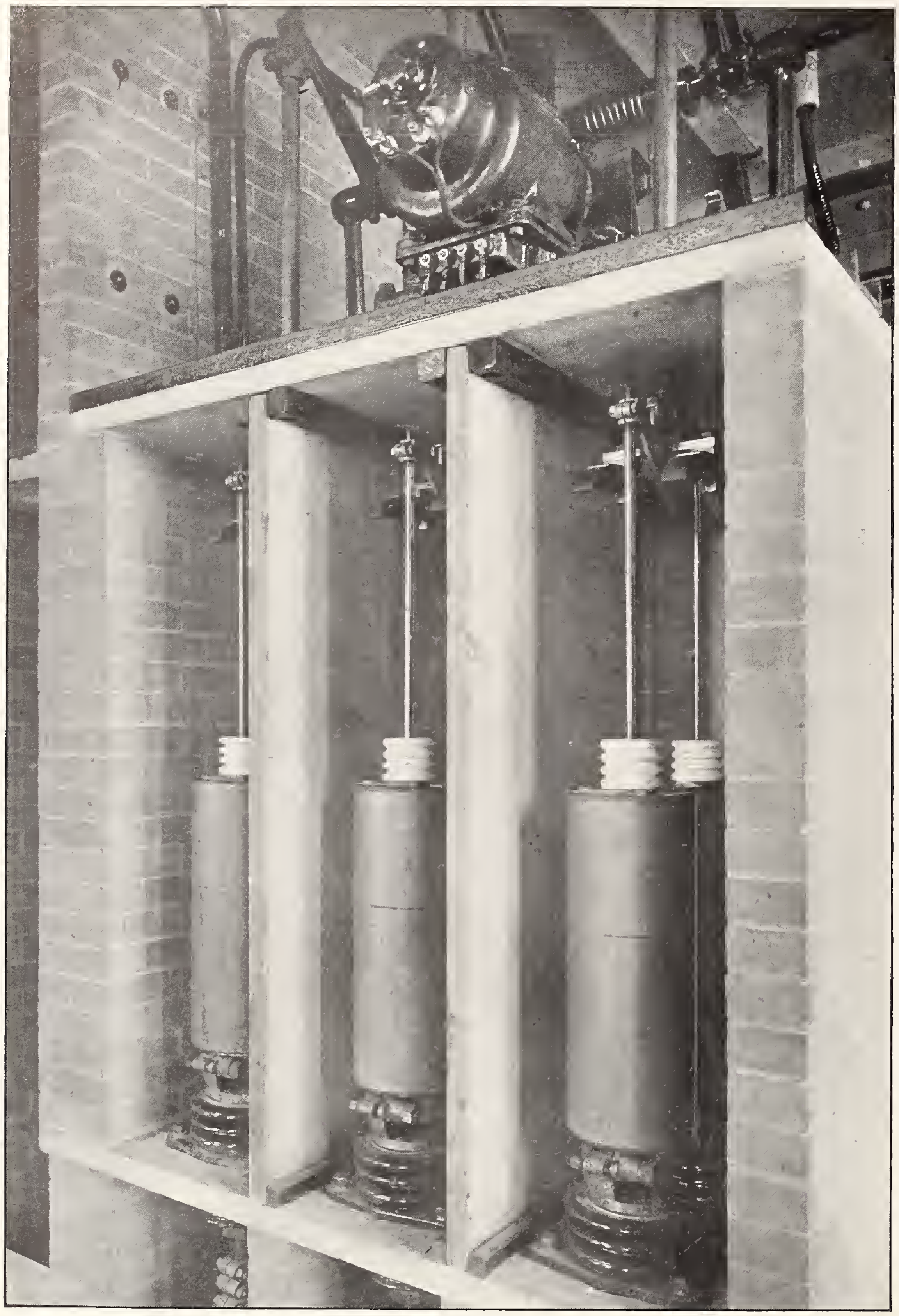


TYPE C AND TYPE E INSULATORS USED BY THE NIAGARA FALLS POWER COMPANY

The Lawrenceville test demonstrated the possibilities of the transformer in reducing the cost of transmitting circuits; the invention of the polyphase motor furnished the means of utilizing the transmitted power for power purposes, and the adoption of polyphase alternating currents by the Cataract Construction Company for the great works at Niagara Falls sealed the commercial success of the system. An excellent meter for alternating currents had been invented and perfected by Shallenberger as early as 1888, and Elihu Thomson also had produced an effective meter for the same kind of service.

But the invention of the transformer, the motor, and the meter left still to be developed much apparatus of prime importance in the construction of the complete and effective plant for transmission and distribution of power by electricity. Switches, operated automatically or otherwise, and adapted to high-potential circuits; insulators for overhead lines and insulation for underground cables; devices for protecting apparatus against the effects of lightning,—all these and other adjuncts, now deemed essential, were still in the future in 1893 so far as heavy power circuits carrying high potentials were concerned, and still in the future also was the question how best to aggregate the complicated apparatus of a transmission system,—one of the great questions of engineering practice which still receives answers varying in respect to impor-


RUBBER-INSULATED, STEEL-ARMORED, SINGLE-CONDUCTOR CABLE FOR SUBMARINE WORK, AS USED BY THE INTERBOROUGH RAPID TRANSIT CO., OF NEW YORK



A MOTOR-OPERATED OIL SWITCH FOR 11,000-VOLT THREE-PHASE CIRCUITS, MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

tant details, but varying far less than they did ten year ago. There remained also the training of men and the development of effective organizations for operation,—a work in itself requiring time, thought, and painstaking effort.

Thanks to Hopkinson, Kapp, Schmid, Brown and others, the art of dynamo design had been developed to a point where it became possible to predetermine the constants of a dynamo, and to design and build in full confidence that the results attained under test would coincide with expectation based upon calculations. The transformer, the motor and the meter placed us in possession of means for delivering and measuring power at a distance; but, as has been indicated, much remained to be done in the development of a reliable system.

It should be noted also that the development of apparatus for electric transmission thus far has been effected necessarily not with reference to fixed ultimate conditions, but with reference to conditions which are constantly changing by reason of the demand for higher and still higher potentials, and by reason of the increased complexity of circuits which results from the growth of existing plants. As the possibility of bringing greater distances becomes apparent, the demand for increased potentials makes itself felt, and every important increase of potential implies corresponding increase in insulation of circuits, including transformers, switches and all devices connected therewith.

Again, as a given power company extends the sale of its product, every additional user of power implies additional apparatus connected to the circuits and increased risk of interruption of the general supply of power to customers of the company. Increase of potential must be met by improvement in insulation, and interruptions due to aggregate length and complexity of an interconnected system of conductors must be met by improvement in automatic circuit-breaking devices, arranged with reference to the location of interruptions of service due to failure of insulation or other causes. The fact that during the past ten years the rate of interest upon capital has been decreasing in America has, doubtless, tended to lessen in some degree the force of the argument in favor of a rapid increase in potentials adopted for new plants; but the reasoning which is brought to bear upon such questions as the selection of potential too often has little connection, or at least little conscious connection, with such matters as a progressive fall in rates of interest.

A subject that has received less attention than it deserves is the difficulty of maintaining an uninterrupted supply of power to motors, lamps, and other translating devices used by customers which results from increased lengths of conductors and increased numbers of translating devices connected to a single source of supply. Electrical engineers are not accustomed to enlarge upon the subject of interruptions of service, but the first step in the correction of defects is recognition of their existence, and reference to this phase of the general subject may be useful.

Obviously, interruptions of service may have their origin in the power plant, in the transmitting circuits, or in apparatus located upon the premises of the user. Other things being equal, those due to line troubles will vary with the length of the line, as has been clearly recognized since the earliest days of transmission. Equally obvious, but apparently less clearly recognized, is the fact that a plant delivering power to a dozen users over a line of equal length faces an increased risk of interruption of service by reason of the addition of a number of branch circuits at the receiving end of the line, and connection to the system of a dozen outfits of apparatus in

users' premises in place of one. Where it happens necessarily, as at Buffalo, at Milan, and at a few other places, that a very considerable number of users are supplied through cables placed underground, which cables, in turn, receive through transforming stations their supply from overhead transmitting circuits extending across country from the water-power, the difficulties in the way of maintaining an uninterrupted supply of power become very serious.

Imagine, if you please, that in a given city a score of separate steam engines are used to drive line shafts in twenty factories and mills. Each of these engines is liable to a certain number of accidental interruptions of service, averaging, perhaps, one per annum. If, for the twenty steam plants, twenty electric motors, supplied through an interconnected system of conductors, be substituted, it is evident that effective means must be adopted to prevent an accident to one motor, resulting in interruption of service in the twenty factories and mills; otherwise if accidents causing interruption average the same with motors as with steam plants, each user will suffer from twenty interruptions per annum instead of from one.

It may be noted still further that the user who philosophically bears with an interruption caused by apparatus owned by himself is usually far from philosophical when inconvenienced by interruptions of service due primarily to failure of other people's machinery. The reasons for adopting effective means for preventing interruptions of service, therefore, increase in a ratio greater than the increase in number of users.

Unfortunately, the complete solution of the problem cannot be found in the adoption of the fuse or safety-link, which is generally and satisfactorily used in dealing with the similar problem which arises in supplying lamps and motors connected to the great direct-current networks in the large cities, since in such cases as that of Buffalo the distances involved in the local distribution are so great as to make the use of high-potential circuits to more than one transforming station imperative, and with circuits conveying alternating currents at 10,000 volts or even at 2000 volts ordinary fuse strips are altogether inapplicable, while nine-tenths of the special devices which have been proposed to take their place are equally useless.

The problem is made still more difficult by the phenomena of resonance and so-called electric surging, the latter of which always follows a sudden disturbance of potential of the system, while the former, under certain conditions of capacity, inductance, and frequency is liable to develop potentials capable of breaking down the most perfect insulation available at the present time. Obviously here is a fine opportunity for the exercise of skill, sound judgment, and perhaps even inventive ability upon the part of the engineer who lays out a system of high-potential alternating-current distribution destined to supply power at some future time, if not at the outstart, to a large number of users distributed over territory too extensive to be reached by direct current.

The first thing to be done is, of course, to secure throughout the system the most perfect insulation that is practicable. Could the insulation be maintained perfect in all parts, nothing more would be needed. This, unfortunately, is not the case, and it becomes necessary, therefore, to lay out such a system of distribution with the greatest possible care, adopting effective means for localizing the interruption which can result from a failure of insulation in any part of the system.

Much has been done since 1893 to overcome the difficulties faced by the companies which first ventured into the field of polyphase transmission and distribution, but there is still room for material improvement. The insulation of cables has made wonderful progress, as have also glass and porcelain insulators for overhead lines, although the quality of American porcelain is not yet equal to that of European porcelain used for the same purpose.

The time-limit circuit-breaker, intelligently applied, is of great value in lessening the evil consequence of failure of insulation by localizing the resultant interruption of service; but the reversed current circuit-breaker, first used by Andrews, at Hastings, England, which should be an equally valuable adjunct to a transmission plant, is not yet available in thoroughly satisfactory form. The extraordinary development of the oil switch in recent years in America, following, but quickly surpassing, European practice, has furnished an effective solution to many of the vexing questions of switchboard practice which caused so much trouble a few years ago. The insulation of dynamos to-day is such that the generation of currents at 11,000 volts is effected with a factor of safety equal to what was possible ten years ago with generated potentials of 2200 volts, and the advance in construction of transformers is almost equally striking.

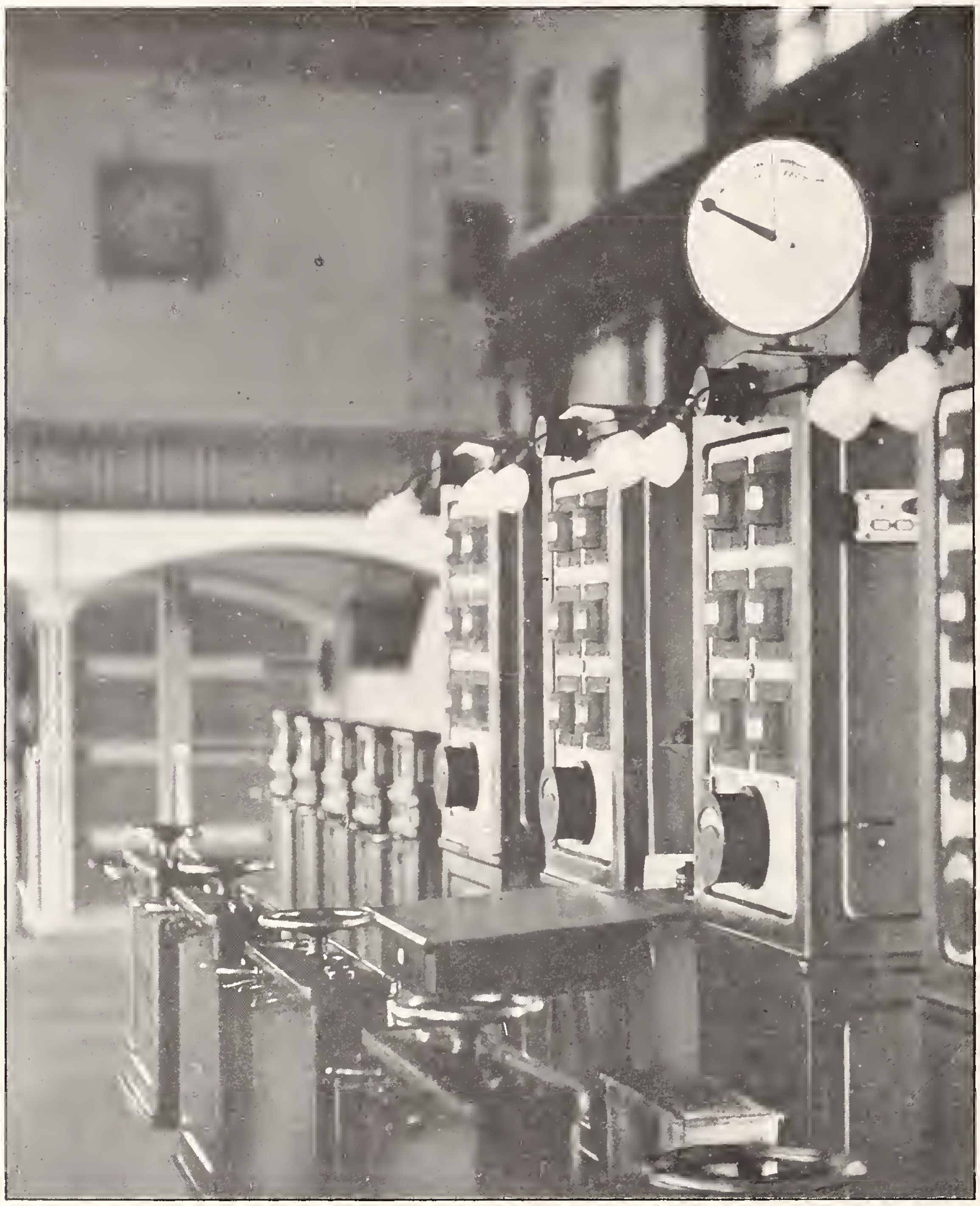
PORCELAIN INSULATORS FOR HIGH-POTENTIAL CIRCUITS

In large plants the general adoption of the method of operating switches in the power circuits at a distance from the operator by means of compressed air or electricity, insuring safety of the operator, has resulted in great gain in certainty of operation. To this end also have contributed a number of valuable auxiliary devices, such as the ingenious and effective synchronism indicator invented by Mr. Paul M. Lincoln, the diagrammatic arrangement of control switches, which places under the eye of the operator at all times an accurate diagram of connections existing throughout the system, various improvements in regulating and governing mechanism of engines, and more particularly of hydraulic

turbines, and, most important of all, perhaps, the development of devices for the protection of electric apparatus against the effects of atmospheric electricity.

It may be interesting to refer briefly to some of the more important of these improvements of the last decade. As regards means available for transmission, the most striking development is the rapid evolution of cables insulated by paper, treated with resinous oils. They are necessarily lead-sheathed to protect the insulation against moisture, and if the sheath be preserved and the cables be not operated at temperatures exceeding 80 C. degrees, there appears to be no reason to doubt their durability. In the city of New York, the Manhattan division of the Interborough Rapid Transit Company now has in use upwards of 120 miles of cable of this character, operating at a potential of 10,500 volts, and during the last nine months there have been only two failures of cable insulation, one of which, however, did not cause any interruption of service.

At St. Paul, Minn., the gas light company has, for the past four years, successfully operated cable of this kind under a potential exceeding 20,000 volts, and recently in developing plans for an important transmission project I have received from two reliable manufacturing companies quotations upon paper-insulated cables guaranteed for service under a potential of 33,000 volts, alternating. There is no reason to doubt that cable of this type, constructed under proper specifications and with sufficient care, may now be considered thoroughly reliable for commercial service under such potentials as these, provided proper precautions are observed in the arrangement of circuits and in the installation of protective devices to prevent such cables being subjected for any appreciable length of time to potentials materially exceeding the working potentials for which they are intended. The upper view on page 283 shows the construction of three-conductor cable as used by the Interborough Rapid Transit Company for 11,000-volt, three-phase distribution in ducts.

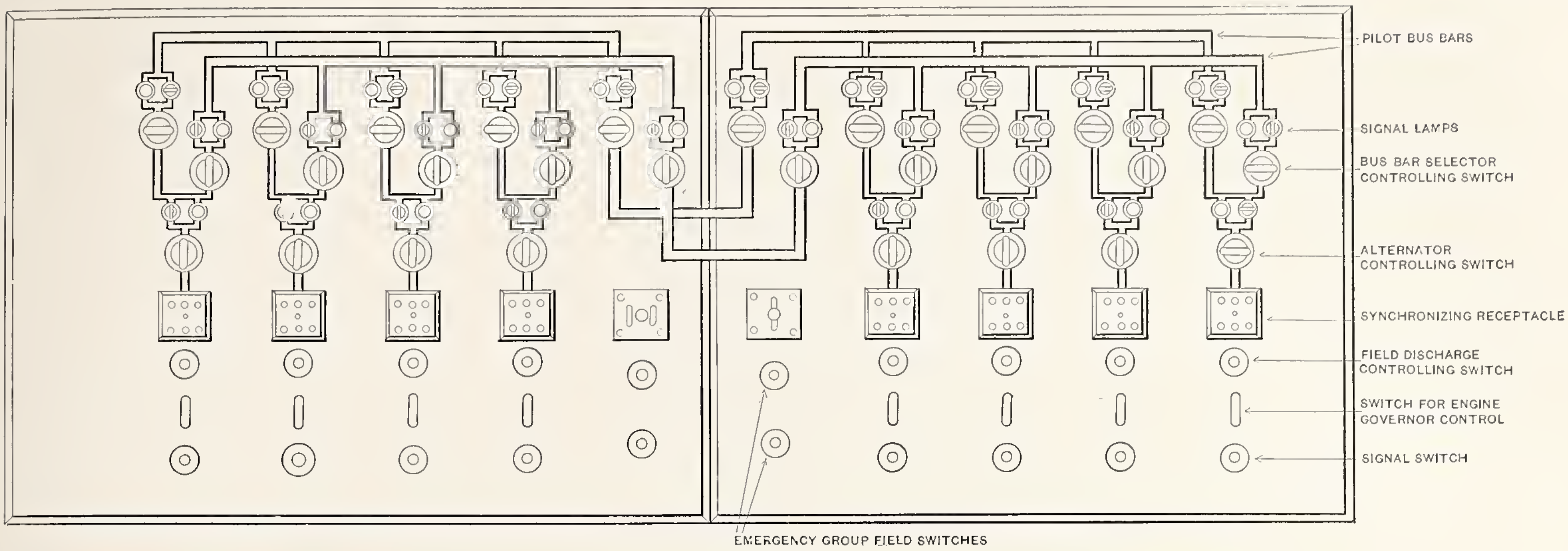

LINCOLN SYNCHRONISM INDICATOR AS USED BY THE NIAGARA FALLS POWER COMPANY

The illustrations on pages 283 and 285 show, respectively, cross sections of three-conductor, rubber-insulated, steel armored cable and single-conductor, rubber-insulated, steel armored cable, as used by the same company in submarine work.

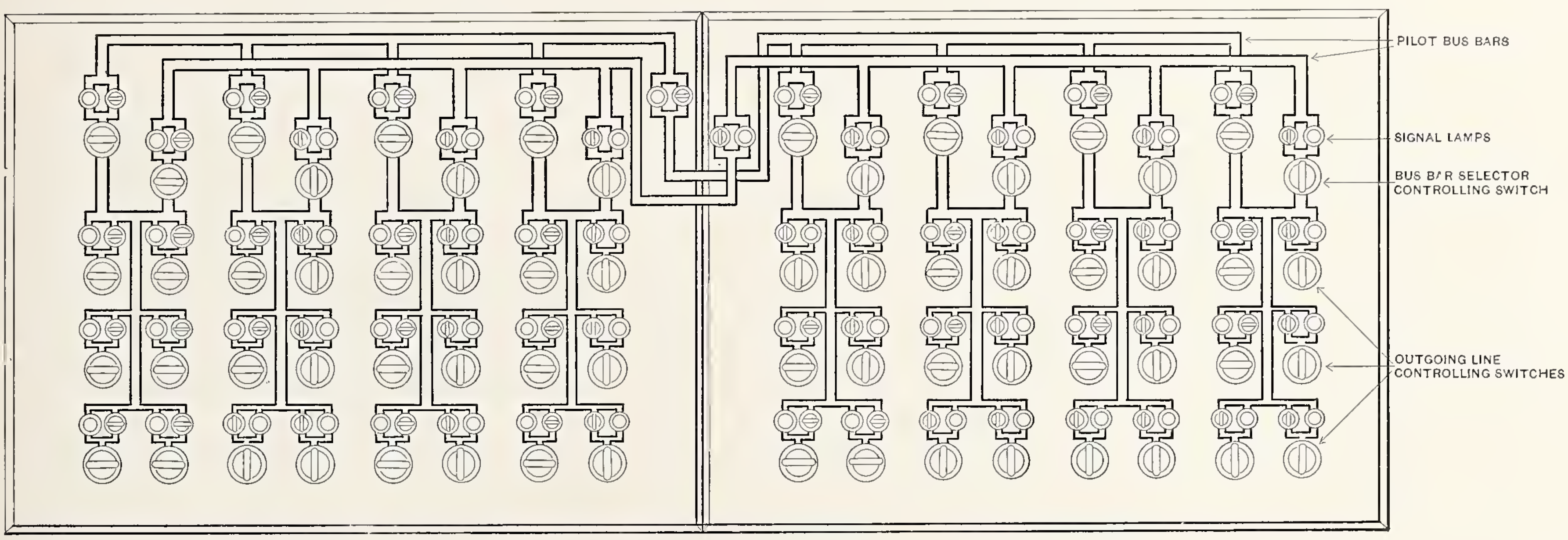
Methods of laying cables also have greatly improved. In the United States they are now usually laid in tile ducts, set in concrete. Much of this duct work is still badly done, particularly with reference to the dissipation of heat, due to currents traversing the cables; but general practice in this respect has improved greatly within the last two or three years. The two line illustrations on page 284 show, respectively, a cross section of a cable conduit and a cross section of a manhole as used by the Manhattan division of the Interborough Rapid Transit Company.

Insulators for overhead lines have been very radically improved since 1893. The insulator used in the Frankfort-Lauffen transmission employed an oil cup to decrease surface leakage. Dust and other material, accumulating upon the surface of the oil, destroy its insulating value, and this type of insulator is, therefore, not now used commercially. The 10,000-volt plant at Pomona and San Bernardino, Cal., installed in 1890 and still in successful operation, uses a double-petticoat glass insulator, designed by Morris, of the Westinghouse Company, and the writer, and in 1895 this insulator was successfully used by Mershon during the high-potential tests which he conducted at Telluride, Col., under a potential of 45,000 volts.

The so-called "Type C" insulator, as used by the Niagara Falls Power Company upon the first pole line, erected between the falls and Buffalo, and the "Type E" insulator, as used upon the second pole line, erected in 1900, are shown in section on page 285. The former was particularly defective in respect to its mechanical attachment to the pin, which was but $\frac{7}{8}$ inch in diameter at the top, while the number of screw threads engaging pin with insulator was but six. The pin used with the "Type E" insulator is $1\frac{1}{2}$ inches in diameter at the top, and nine threads secure the insulator to the pin. The Niagara Falls Power Company increased the line potential between Niagara and Buffalo from 11,000 volts to 22,000 volts in the



ALTERNATOR CONTROLLING BENCH BOARD USED BY THE MANHATTAN RAILWAY COMPANY, NEW YORK



ALTERNATING CURRENT FEEDER CONTROLLING BENCH BOARD USED BY THE MANHATTAN RAILWAY COMPANY

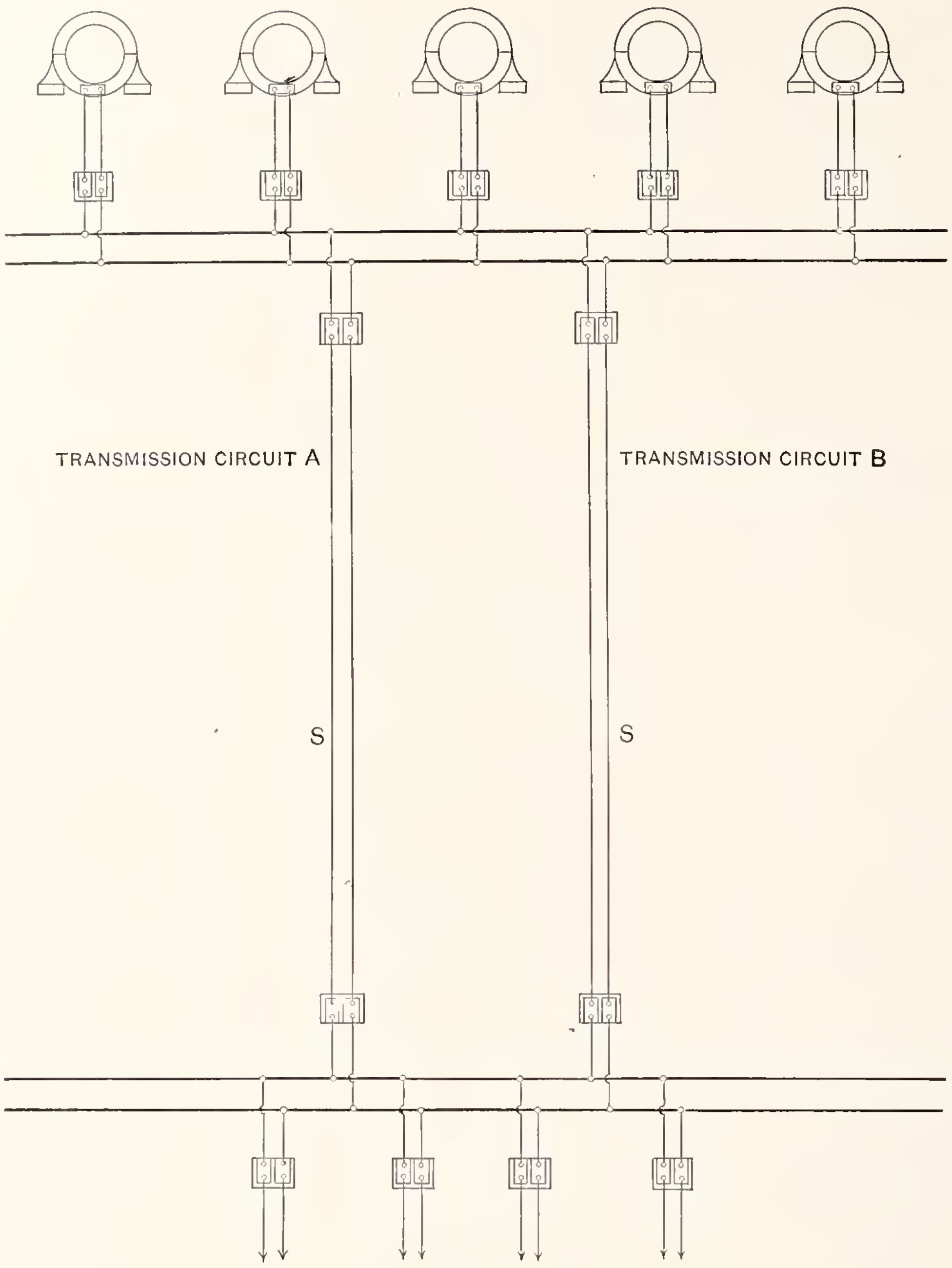
spring of 1901, and since that time has been replacing gradually the "Type C" insulators on the old line by insulators of the newer type, which have been very successful.

On page 287 are shown illustrations of three insulators. The smallest is "Type E," as now used at Niagara, while the largest is an insulator made by the Locke Insulator Manufacturing Company, of Victor, N. Y., for very high voltage. This insulator has been selected for the 101-mile transmission plant of the Guanajuato Power & Electric Company, in Mexico, which company is now using successfully a potential of 60,000 volts. The insulator of intermediate size is one which the writer designed several years ago for line potentials of from 40,000 to 50,000 volts. It is the largest porcelain insulator made in a single piece, the Locke insulator being made in several concentric materials or cups which are cemented together. Many other insulators effective for line potentials up to 50,000 volts are now available, and some of the more recent of these are designed for pins of adequate size.

Probably the most valuable single addition to apparatus developed since 1893 for high-potential transmission is the electrically operated oil switch. The illustration on page 286 gives an excellent idea of its construction, as built by the General Electric Company, of Schenectady, N. Y., for 11,000-volt, three-phase circuits.

Two breaks are provided for each of the three sides of the circuit, and in opening the circuit the break is made under oil contained in large metal cylinders. Each cylinder contains a fixed terminal. When the switch is closed, current passes from one terminal of each pair to the other through two vertical rods of copper connected at the upper ends. The switch parts belonging to each of the three sides of the circuit are separated from all other parts of the switch and its mechanism by being enclosed in a brick compartment with vertical partitions of soapstone, as shown in the illustration. The moving parts of the switch are operated by mechanism located upon the top of the brick compartment, this mechanism being, in turn, actuated by an electric motor which is controlled by circuits extending from the control board, or pilot board as it is sometimes called. At the control board the operator has before him a small switch, sometimes two, corresponding to each of the large three-phase switches, and the movements of the latter are controlled by opening and closing the former.

The plan of opening and closing switches located at a distance from the operator by compressed air or electricity was first adopted, I believe, by the Westinghouse Company in connection with the switchgear installed in the first power house of the Niagara Falls Power Company. In that plant the plan demonstrated its value, and it is now generally and in fact almost necessarily adopted in the case of all large modern plants. The sense of security enjoyed by the operator while controlling these great switches at a distance results in con-



TYPICAL DIAGRAM ILLUSTRATING USE OF TIME LIMIT AND REVERSED CURRENT CIRCUIT BREAKERS

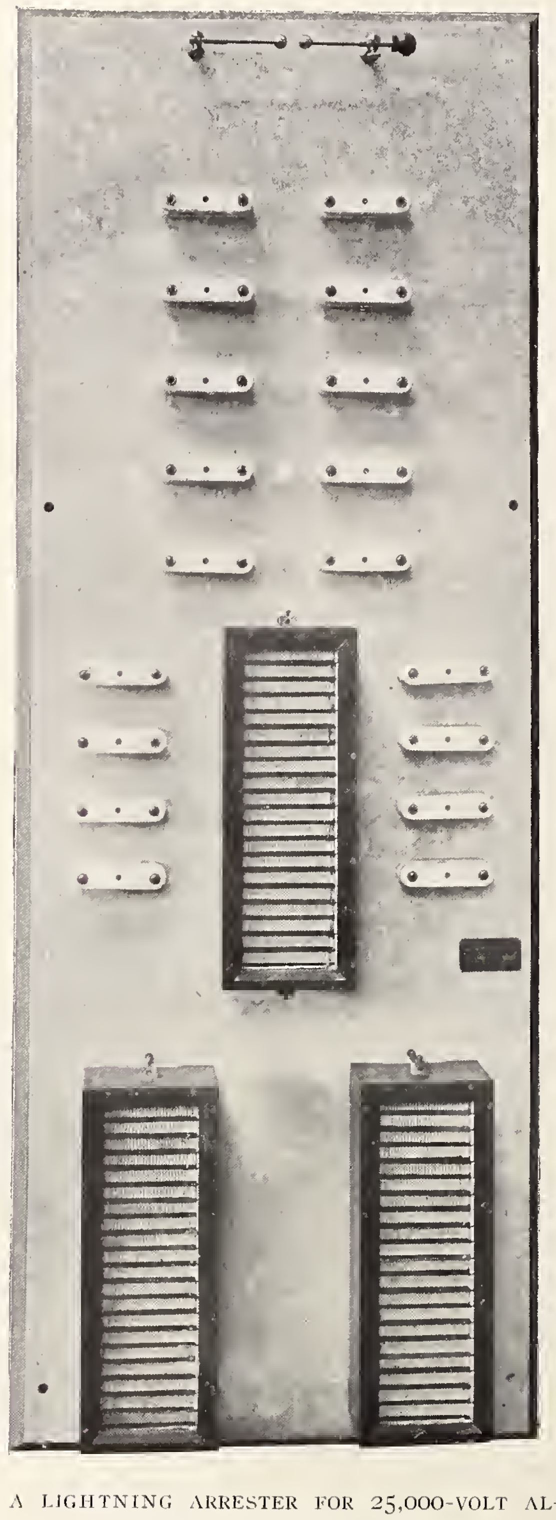
fidence which goes far to insure that precision which is so absolutely essential.

At the Manhattan Railway power plant in New York City sixty-six switches of this type are installed, and, on the average, have been in use about eighteen months. During that time not one of these switches has failed to operate as and when expected, and while some of them have been called upon to open automatically circuits in which extremely heavy short-circuited currents were flowing, they have done this without damage other than some spilling of oil from the oil cups.

The illustration on page 288 shows a synchronism indicator as installed upon Switchboard No. 1 in Power House No. 1 at Niagara Falls. This synchronism indicator, invented by Mr. Paul M. Lincoln, is an ingenious and most useful adjunct to a power plant using alternators. When an alternator is to be connected in parallel to bus bars supplied by one or more alternators, the synchronism indicator is connected to the circuits through suitable transformers and becomes a perfect guide to the operator. The index arm of the indicator revolves at a speed proportional to the difference in speed between the alternator to be synchronized and the alternators supplying the bus bars, and it shows also which of the two is running at the higher speed. As used at Niagara, it is of very large size, and is mounted upon a vertical shaft which makes it possible to turn the face of the instrument so that it becomes visible not only to the operator upon the switchboard who throws the switches, but also to the governor attendant upon the floor who is adjusting the speed of the alternator preliminary to the operation of synchronizing.

Still another comparatively recent auxiliary of value in the operation of large plants is the diagrammatic pilot board shown in the illustrations on page 289. In this arrangement of the operating switches which control the power switches at a distance, dummy bus bars and other apparent (but not real) connections are provided and assembled in connection with the operating switches in such a way as to place before the operator at all times a diagram of the existing connections of the power circuits. Every time he changes the position of the pilot or control switches he alters the diagram to conform to the resulting connections of the power circuits, the diagram as indicated to the eye by handles of the pilot switches being corroborated by red and green signal lamps, one or the other of which is lighted when the corresponding power switch reaches the end of its travel in the movement incident to opening or closing the circuit. The illustrations on pages 114 and 115 show the diagrammatic pilot board and the instrument board as used for controlling the operation of eight 5000-K.W. alternators at the Manhattan power plant.

The development of the oil switch, which is capable not only of reliably making and breaking circuits in ordinary operation of the plant, but also of opening circuits traversed by short-



A LIGHTNING ARRESTER FOR 25,000-VOLT ALTERNATING CURRENT CIRCUITS

circuiting currents as a result of failure of insulation, opens the way to the effectice use of the time-limit relay attachment and of the reverse current relay attachment for such switches used as automatic circuit-breakers. The respective functions of these two relay attachments can be described best by reference to the diagram on this page.

This diagram shows the essential connections of power circuits in a power plant comprising five alternators and transmitting power to a substation through two cables or overhead circuits. To simplify the diagram, the arrangement shown is that required for a single-phase apparatus, and but one set of bus bars is shown in the power house and also in the sub-station. From the sub-station four circuits serve to distribute power at low potential. If no time-limit circuit-breakers be used, a heavy short-circuit upon one of the distributing circuits from the sub-station may result in opening not only the circuit-breaker or fuse located in the sub-station to cut off the particular circuit affected, but also the circuit-breakers or other devices located at the power house and intended to cut off one or the other of the transmission circuits in case of a heavy short-circuit between power house and sub-station.

Instances have been known where even the automatic circuit-opening devices between dynamos and bus bars have been opened as a result of a short circuit beyond the transformers in the sub-station. If the time-limit relay be be used in connection with the circuit-breakers, and if it be set, say, for three seconds in the case of circuit-breakers between dynamos and bus bars, one second in the case of circuit-breakers in the transmission circuits at the power house end of the line and for instantaneous operation in distributing circuits from sub-station, the circuit-breaker in the distributing circuits at the sub-station may be relied upon to open before those in the transmission circuit at the power house, and, of course, also before those in the dynamo circuits at the power house can open. The interruption of service, therefore, which results from failure of insulation in one of the distributing circuits from the sub-station will be limited to the supply of power through the particular distributing circuit affected.

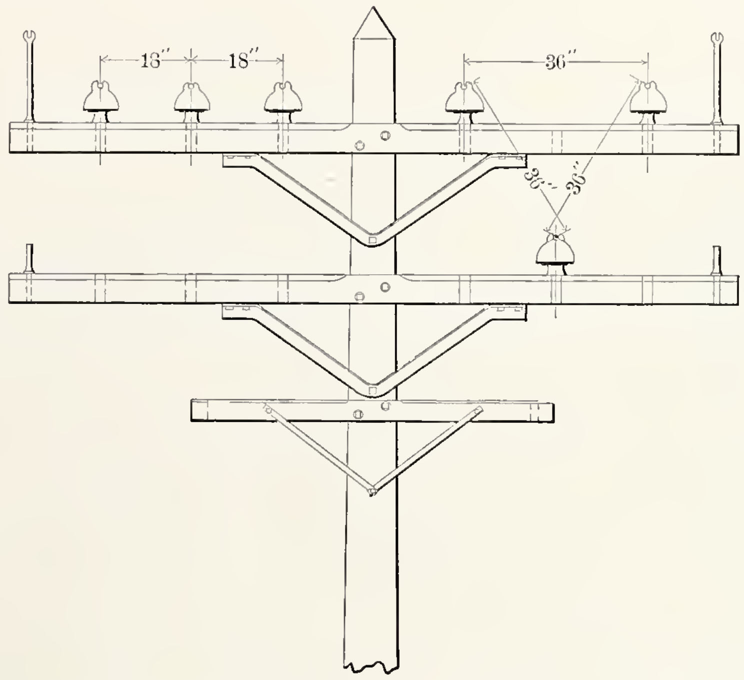
The reverse current circuit-breaker, which should be an equally valuable adjunct to a transmission plant, unfortunately, as has been said, is not yet available in thoroughly satisfactory form. Andrews used it between alternators and bus bars for the purpose of cutting out an alternator which might become short-circuited. It is equally applicable, of course, to alternating-current circuits between a a power house and sub-station, provided the circuits are connected in multiple with each other at both ends of the line. Referring again to the diagram on page 290, we may imagine that a short-circuit occurs on a transmission circuit, designated *A*, at the instant of maximum flow of current in one direction, which, for convenience, we may call positive. It is evident that the instant the insulation between conductors of circuit *A* is broken down, *e. g.*, at point designated *S*, current will flow from the bus bars at the power house and also from bus bars at the sub-station toward the point *S*. This implies a reversal in the direction of flow of current between the the bus bars at the sub-station and the point *S*, as compared with its direction at the given instant had no short-circuit occurred. This reversal may be utilized to open the circuit-breaker by actuating a relay device.

Practically all of the reversed current relays thus far tried in the United States have proved unsatisfactory by reason of the fact that they require a potential in phase with bus bars at sub-stations, and in case of very heavy short-circuits this potential usually drops below the limit effective for operation. The required potential might be obtained from a small alternator, normally operated in synchronism with the power supply and equipped with a fly-wheel of sufficient size to keep the alternator going at synchronous speed for the necessary fraction of a second after the occurrence of the short-circuit, or perhaps better means might be devised for accomplishing the same purpose.

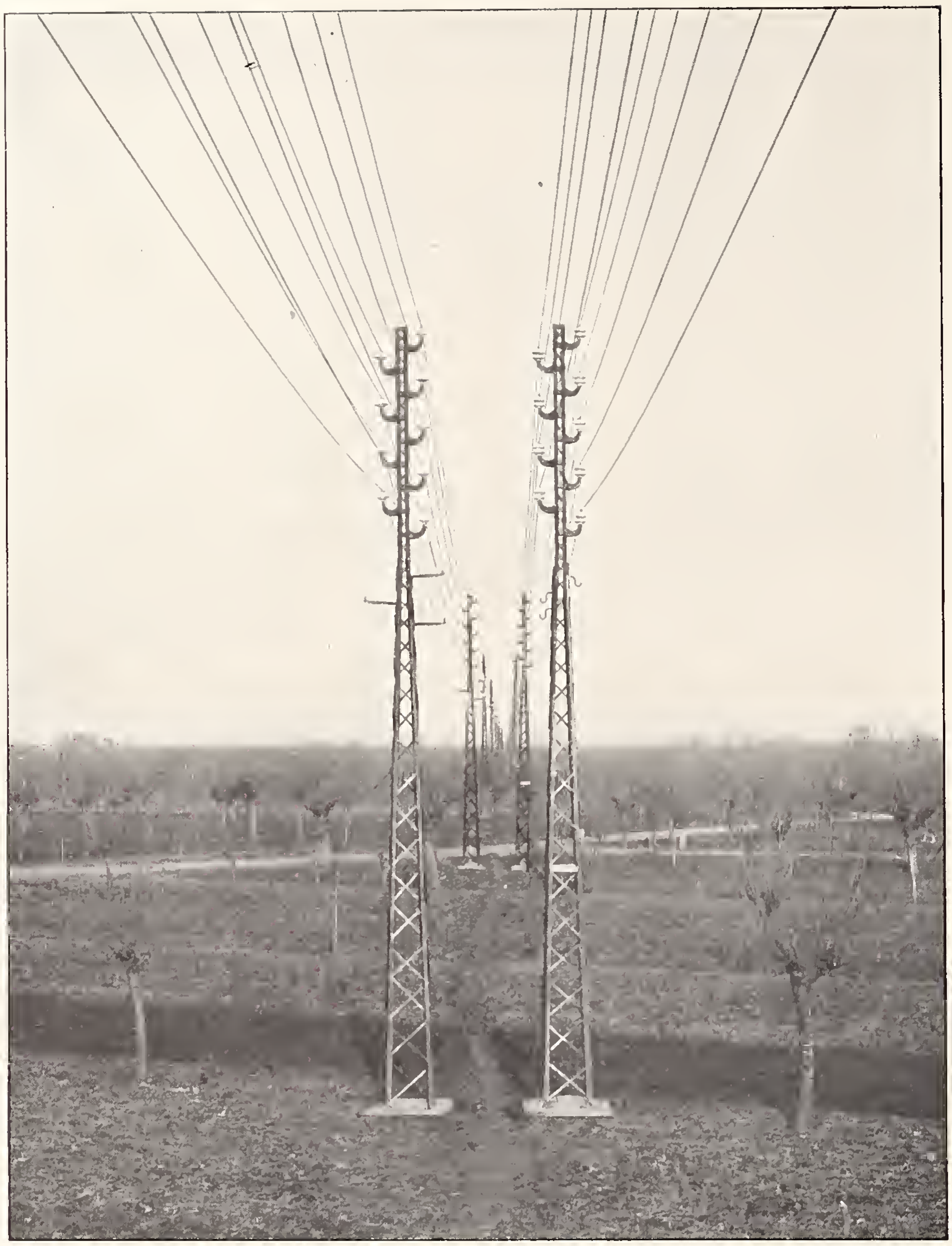
Where three or more circuits between power house and sub-station are available, reversed current relays can be operated by difference in current flowing through the short-circuited line and the other lines, and relays of this type are now upon the market.

Without entering further into discussion of details, it will be evident that proper use of the time-limit relay and of the reversed current relay, in combination with the oil switches now available, afford means for effectively localizing the troubles resulting from any short-circuit in an inter-connected alternating-current system of distribution which is carefully laid out with a view to such localization.

Perhaps no adjunct of a successful transmission plant employing overhead circuits is more important than the lightning arrester, and in the development of none has more remarkable progress been made since the days immediately following the Lawrenceville test. For this progress we are indebted chiefly to Alexander J. Wurts. The first alternating-current plants in America used the brass "saw-tooth" arrester which was then in general use by the telegraph companies. Bitter experience soon demonstrated the futility of this device when applied to 1,100-volt, constant-potential circuits, supplied by dynamos having low internal resistance, and it was soon displaced by a flood of ingenious and more or less effective arresters, which, in turn, were effectively superseded by the so-called non-arcing metal arrester discovered by Wurts in 1892. The problem was to provide an easy path from conductor to earth for static electricity due to lightning and to prevent the dynamic current following in the path of the static discharge and short-circuiting the system. This, for po-



POSITION OF INSULATORS ON THE FIRST NIAGARA-BUFFALO POLE LINE



STEEL POLE LINE AND CIRCUITS ON THE MILAN-PADERNO TRANSMISSION, ITALY

tentials up to about 25,000 volts, has been effectively accomplished by means of the non-arcing metal cylinders. For high potentials, the performance of lightning arresters is not yet altogether reliable. The illustration on page 290 shows a modern lightning arrester outfit for 25,000-volt circuit. Detail descriptions have been printed in various technical journals and in advertising publications of manufacturing companies.

As regards line construction, it is to be regretted that few plants in the United States up to the present time have erected transmission circuits which, from the standpoint of permanence, compare favorably with approved European practice as illustrated, for example, in the illustration on this page, showing the steel pole line used between Paderno and Milan. For this illustration I am indebted to Mr. Guido Semenza, the very able engineer of this important and interesting plant. Nearly all pole lines in America are of wood, and, so far as insulation is concerned, there is much to be said in favor of this material. In my opinion, however, the lines of the future will use steel poles or towers, widely spaced, and will rely for insulation exclusively upon the insulators to which the conductors are attached. The idea of using steel poles is not new in America.

The illustration on page 293 shows a design for a steel pole carrying two transmission circuits as designed under the writer's direction in 1894 by the Pittsburg Bridge Company, and submitted to the Cataract Construction Company with reference to the then proposed transmission from Niagara to Buffalo. It will be noted that the three conductors of each circuit are triangled, the sides of the equilateral triangle measuring 36 inches.

Unfortunately, this plan was rejected, and the first pole line carrying two circuits was erected between Niagara Falls and Buffalo in line with the plan illustrated on page 291, both circuits originally being carried upon the upper cross-arm, the three wires constituting each circuit being spaced at intervals of 18 inches and carried at the same level as shown at the left.

This arrangement was a great temptation to mischievous boys, who threw wires and sticks across the line wire. Owing to the position of the conductors, they inevitably came in contact with at least two sides of the circuit, causing tremendous short-circuits, which blazed along the line until the power was cut off. The light of these short-circuits in some cases was seen at a distance of a mile, and unless the power was cut off at the power house they inevitably resulted in burning off and dropping the conductors of the transmission circuit. The triangular arrangement of conductors illustrated on the right-hand side of the drawing on page 291 shows the location of the conductors of the first two circuits as subsequently located. In this position they have given little trouble.

Enough has been said to show engineers who to-day are designing electric power plants having available for use much highly important, if not absolutely essential, apparatus which did not exist ten years ago. Efficiency of dynamo, transformer and motor has improved since then, but it has gained little as compared with the development of such auxiliary apparatus as has been referred to here. The latest dynamo installed at Niagara is not materially more efficient than the first one which was put into commercial operation there in 1895; but line insulators, cable insulation, switches and relay devices for automatic circuit-breakers are incomparably superior to any that existed at that time.

Doubtless further improvement in respect to details of construction is to be expected, but the apparatus available to-day is such that transmission at 60,000 volts should be more reliable than transmission at 6000 volts was ten years ago. Accurate and extensive knowledge and sound judgment the engineer who designs and installs such a plant must have, but the materials are now available if he knows where to find and how to use them.

Considering the probabilities of future development of electric transmission it is reasonable to expect that the utilization of water powers will continue until practically all of any considerable magnitude are put to work. The ability to employ higher potentials means ability to span greater distances, and thus markets will be found for water powers which hitherto have been deemed too remote from industrial markets for profitable utilization. Improved reliability and gradually les-

sening cost of apparatus will co-operate influentially toward this result, as will also the decrease in rates of interest upon capital which has been so marked in recent years.

It is to be expected also that power plants using steam or gas engines to drive dynamos and distribute power electrically over large districts will be constructed.

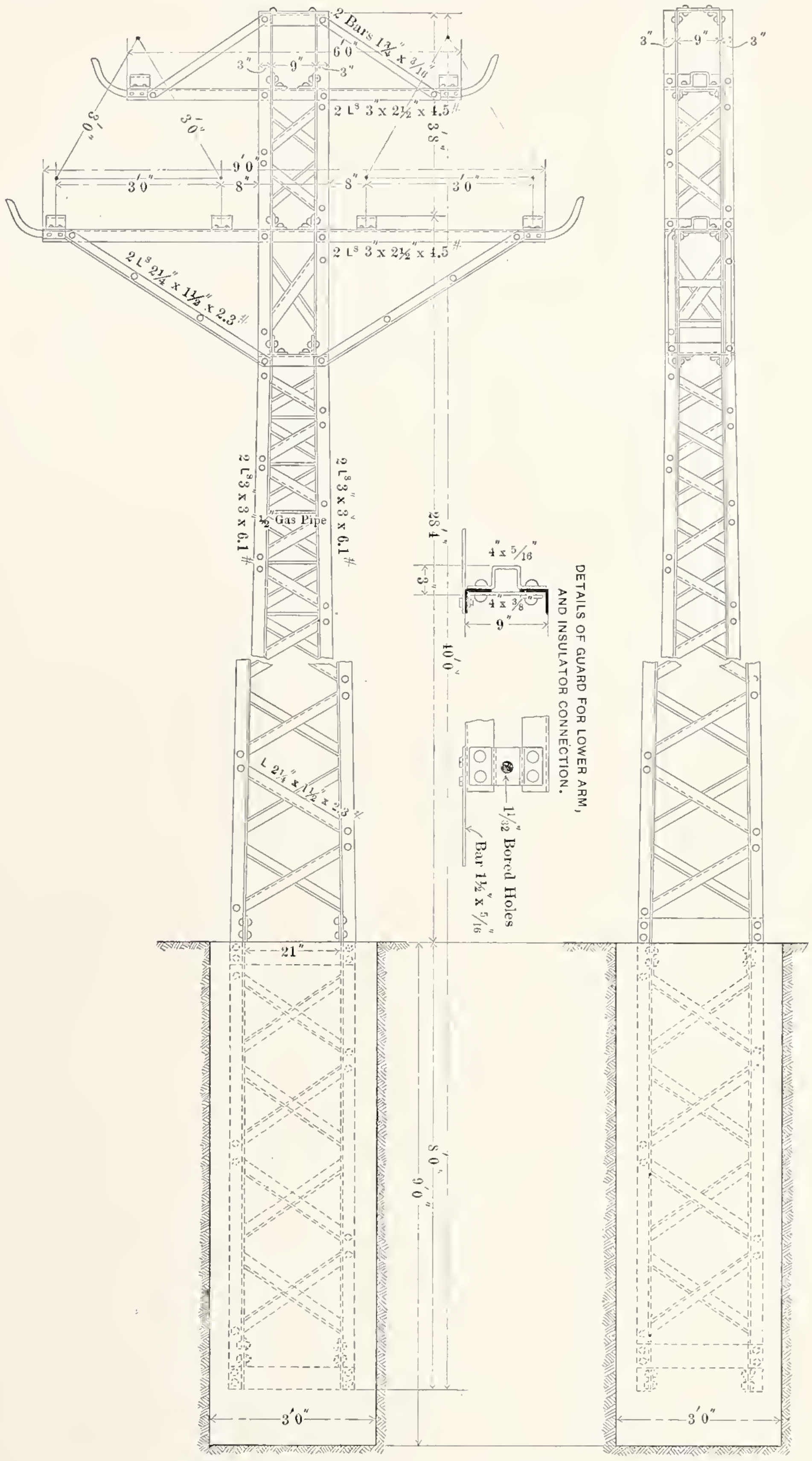
The opportunity for profit rests chiefly upon three facts:—(1) that power can be produced more economically by a very large steam plant than by a small one; (2) that the aggregate power which a central station plant, supplying a certain district, is called upon to develop at any given time is very much less than the sum of the maximum outputs of the small plants required to do the same work; and (3) that an electric motor occupies much less space and requires less attention than a steam plant. A 50,000-H. P. steam plant, supplying electric power for general purposes to a district having a radius of 50 miles, will burn about 3 pounds of coal per average K. W. hour delivered throughout the district, while the average consumption of coal by the steam plants which such a central power plant would displace is usually not less than 10 pounds per K. W. hour.

As regards ratio of the maximum output of the central station to the sum of the maximum outputs of the displaced small plants, definite generalization is impossible, because everything will depend upon the kind of work done by the small plants. I think it safe, however, to say that this ratio will rarely, if ever, be higher than 2 to 3, and in some instances which have come under my observation it is as low as 1 to 3. In other words, a 50,000 H. P. central station plant will rarely, if ever, fail to do the work of small plants aggregating 75,000 H. P., and in some instances will be capable of doing the work of small plants aggregating 150,000 H. P.

Transmission of power from coal fields to large cities works out much less favorably, since in this case it must compete with the alternative plan of transporting the coal to the city or to a point near it and there generating electric power in a steam plant equally economical and equally deriving the benefit which results from the fact that a single large plant can displace a large number of small plants whose aggregate output considerably exceeds its own. In this case, the plant located at a distance from the city must be larger by an amount equivalent to the maximum losses in transmission.

But what may prove to be the greatest of all fields for alternating-current transmission now confronts us in the application of electricity to the operation of railways. The successful substitution of electricity for steam by Ganz & Co., of Buda-Pesth, upon the Valtelina line, in Italy, by which a great economy has been effected in cost of operation of a railway more than 60 miles long, is an object lesson of great significance. Freight as well as passenger traffic is handled successfully under very severe conditions of grade, curvature and climate, and the economy resulting from the substitution of electricity for steam challenges the attention of railway managers and engineers.

The recent high-speed trials at Zossen, Germany, in which a 15-ton car, operated electrically, attained a speed exceeding 131 miles an hour, invite attention in the same direction, and the development of two single-phase, alternating-current motors in America and of two similar motors in Europe, each of which is stated to meet effectively the requirements of railway service, mark by far the most interesting and important practical step of this new century in the use of electricity for power purposes.



A 40-FOOT STEEL POLE DESIGNED BY THE PITTSBURG BRIDGE COMPANY

Machinery Hall, unlike the other buildings at the St. Louis World's Fair, is open until 11 p. m.

The Storage Battery in Small Central Stations

By J. M. S. WARING

From a Paper read before the Northwestern Electrical Association

OWING to the impossibility of drawing any distinct line separating storage battery practice in small central stations from that in the larger stations, and to the fact that many or most of the economies and advantages effected are common to all direct-current stations, irrespective of their output, I have decided to deal with this subject in the following way:—

First, to cite a battery application peculiar to small stations, and then to dwell briefly on the features common to all central stations.

In the first case the consideration will be that of a lighting station in a small village. In such cases it usually proves unprofitable to furnish continuous service throughout a twenty-four-hour day, as the demand for current during the early morning hours and throughout the greater portion of the day would be so small that the additional shift of men required and the increased fuel consumption on the plant would prohibit the commercial success of the venture.

It is, however, true that the manager of a central station operating only a night schedule is greatly handicapped. In order to secure any great amount of residential lighting business, continuous current must be supplied, as the owner of a residence would naturally demand light during all hours of the night, and would, further, probably demand fan service throughout the day during the summer months. If these facilities cannot be offered to the public, the amount of business of the small central station is necessarily limited.

As an illustration of what has been accomplished along this line I might cite a case in actual practice where the conditions were as follows:—

The plant I have in mind consisted of one 60 and one 120 horse-power non-condensing engine, which, in addition to driving certain machinery, operated two 125-volt generators, one having a capacity of 20 and the other of 25 kilowatts, the two being operated in combination on a three-wire Edison system, with 220 volts across the outside mains. This plant has been operating and supplying a load concentrated within a very small radius. The maximum peak load of 150 amperes was on the station for about an hour and a half in the evening—that is, from 6:30 until 8; it then gradually decreased to about 10 amperes at 11 o'clock at night, and at 12 o'clock the plant was shut down.

An opportunity arose for this plant to obtain the contract for city lighting, but the cost of the necessary transmission line, including poles, copper, etc., amounted to so much that the returns from the city lighting alone would not warrant the investment; however, it was obvious upon investigation that if a sufficient amount of residential lighting could be assured, the investment would become a decidedly paying one, and with this in view a storage battery was installed. This installation made, the station continued to operate for the same number of hours daily. On account of the new business the load was materially increased. From 12 o'clock (midnight) until dusk in the afternoon the entire load was taken care of by the battery.

While this was a three-wire system with 220 volts across the outside mains, only a 110-volt battery was installed, for, during the hours that the battery was operating, the load was so light that by connecting the two outside mains together at the station the system could be operated by a two-wire 110-volt system, and even under these conditions, owing to the light load, the drop was considerably less than when operated as a three-wire system with the maximum load. In this case there was an increase in load, after the installation of the battery, of about 66 2-3 per cent., and an increase in fuel consumption of only about 25 per cent., showing that the cost of fuel per kilowatt-hour was decreased about $37\frac{1}{2}$ per cent., this decreased fuel consumption being due to the fact that the generator set, while operating with the battery, was run at a considerably higher percentage of full load than was the case before, the efficiency being correspondingly increased.

Another instance which occurs to me is similar to the above, with the exception that the plant supplied the adjacent district from a three-wire direct-current system, while in the outlying districts the load was on an alternating system. While this alternating load was extremely heavy during the peak, it was very light during the day, consisting only of a small amount of fan service in the summer months. A battery was installed in this plant which furnished current directly to the direct-current mains and at the same time operated a direct-current motor running a small alternator so that the fans on the alternating-current system could be operated.

These, and cases of a similar nature, are, of course, confined to small plants. Another application of the storage battery, which is irrespective of the size of the plant, is that of a battery operating in conjunction with a water power plant. A number of cases have come before the writer where there was sufficient water power to supply considerably more than the load existing during the greater portion of the twenty-four-hour day, the peak load during the evening hours, however, being in excess of the capacity of the turbines. In this case the value of the battery is apparent, as the generators, while carrying the day load, are charging the battery at the same time, the battery assisting to the extent of its capacity during the peak, thus giving an increased station capacity which would otherwise be only obtainable by the addition of an auxiliary steam plant, with a correspondingly increased cost of operation, which would probably make the investment prohibitive.

There are a number of features which may be briefly mentioned as being of interest to the central station manager, regardless of the size of the plant he is operating. To the central station manager a minimum cost of production and transmission, allied with reliability of service, are essential. The consumer, however, demands that the latter item be not sacrificed in the pursuit of economy. Intermittent service results in a loss of business to the central station, and, while it may be difficult to compute

the expense to which a lighting station is subjected by a ten or fifteen-minute interruption, the official who receives the complaints of his customers fully realizes that a loss of revenue does result from frequent recurrences of this complaint.

The storage battery insures increased economies of production and transmission, at the same time almost entirely preventing interruptions to service. A battery at the source of the direct-current transmission,—that is to say, in either a direct-current power house or a rotary sub-station,—will offset, in the first place, the installation of a corresponding capacity of boilers, engines and generators. In the second case, that of a rotary sub-station—in addition to this apparatus, it will also offset a certain proportion of the static transformers and rotary equipment, with the cost of which apparatus that of the battery will compare favorably. It is of the greatest value as a reserve in either case, tiding over shut-downs occasioned by trouble on any of the apparatus just mentioned, or in the high-tension line in the latter case. The battery, being ever present on the system, is readily available as a reserve.

It further obviates the necessity of carrying boilers under steam in anticipation of a peak load, thus insuring a decreased fuel consumption.

Another familiar application of the storage battery is that of placing it at the center of load on a direct-current system of distribution. When the volume of business in a congested locality covered by a low-tension system of transmission reaches a certain volume (and the more remote this locality is from the central station, the sooner this point is reached), the amount of copper required to care for the power from the central station necessitates an outlay tending to render this system of transmission prohibitive. By the installation of a battery of a capacity sufficient to care for a certain portion of the peak, the amount of copper between the central station and the center of load is decreased to such an extent that the battery investment is decidedly the preferable one from a commercial standpoint.

One of the more recent adaptations of the storage battery, and one of which importance will readily be recognized by central station managers, is its use in connection with direct-current exciters in alternating-current power and lighting plants. With an installation of storage batteries floating at all times on the exciter bus, interruptions of current in the exciter circuit are practically obviated. Reduced fluctuations of the exciter voltage are assured, together with corresponding reductions in the alternating-current voltage fluctuations. Where alternating-current motors are used to drive the exciters, the battery also serves to supply field current when starting up the plant after a shut-down.

An attractive feature in any battery installation is its adaptability to changes of conditions over a very wide range. Its capacity or voltage may be increased or decreased by varying the number of plates per cell or the number of cells in series without affecting in any way the original installation, thus obviating the necessity of anticipating any future increase in business.

It may be said in general that there are few direct-current systems on which the service may not be improved, the liabilities of interruption decreased and the operating expenses minimized, by the use of a storage battery auxiliary.

Steam Railroad Control of Electric Lines

THE New York, New Haven & Hartford Railroad, according to "The Iron Age," are conducting an important experiment in the control of a great system of electric street railways, which is made the more interesting because they are operating also considerable sections of steam road equipped with the third-rail system. In all this the company occupy a rather unique position in recognizing that it is a wise policy for the steam railroad to control the electric lines paralleling its track, and that it is also expedient that the city systems be included. Consequently the New York, New Haven & Hartford interests have been acquiring electric railways for some time, and only recently announcement was made of the purchase of the city system of New Haven, Conn., and the Worcester & Southbridge Street Railway. Considered apart from the economic aspect of such control as it affects the purse of the public, the experiment is important in its influence upon electric railway practice. As such it is being watched by steam and electric railway men, and also by alert manufacturers and dealers in special electric railway equipment, who wish to keep abreast of the new demands that will be made upon them as a consequence of the application of steam railroad ideas and practice upon the newer form of traction.

If the experiment proves successful, as steam railroad men generally believe it will, the example is apt to be followed elsewhere, and those who sell to street railways will find a new order of things as purchasing departments of steam and electric companies are merged. This will apply not only to those who manufacture and sell street railway equipment proper, but also to manufacturers and dealers in the thousand and one things which enter into the equipment of repair and construction shops, power stations, car barns, etc., such as machine tools, iron and steel, and so on. The New York, New Haven & Hartford Company have made their experiment the more searching by placing the management of their street railway interests, aggregating hundreds of miles of track, in the hands of a steam railroad man, who will occupy a newly created vice-presidency in the company's board of officers.

Steam and electric railroad practice have been coming together ever since the beginning of electric traction, yet the electric railway man will not believe that the steam railroad man can successfully cope with the street railway proposition, because the conditions are so different from anything that has confronted him in his domain of private right of ways. Yet the street railway has been rapidly approaching steam road equipment, in roadbed, weight of rails, and weight and size of rolling stock. The steam railroad man can add not a little to conditions of safety on street railways, and here again the market will meet new ideas in appliances to assist in securing safety for the public. There seems to be little doubt that steam railroad management of electric railways will be a not unimportant step in the evolution of the newer method of traction.

The bracing of poles for electric transmission lines by means of head guys from one pole to another appears useless as a protection against windstorms. At a recent meeting of the Chicago branch of the American Institute of Electrical Engineers, the statement was made that a pole line protected by head guys had entirely gone down, while pole lines alongside of it protected by side guys had remained intact.

The Automobile Club of America has made the official awards for the commercial vehicle test, which took place in New York from April 4 to 9, inclusive. Of the first prizes offered in the seven classes, three were won by electric vehicles, three by gasoline vehicles, and one by a combination gasoline-electric vehicle.

The Electric Furnace

By J. WRIGHT

THERE are few inventions in the electrical field which have benefited the chemist and metallurgist more than that comprised under the general title of "electric furnace." Up to, comparatively speaking, a few years ago, the highest attainable temperature by any known artificial means was 1800 degrees Centigrade, or, possibly, with exceptional facilities and the exercise of great care, as high a temperature as 2000 degrees Centigrade may, in some cases, have been attained, though the exact limit is questionable; certainly it does not rise much above the latter figure. Thanks, however to the indefatigable researches of Moissan, Siemens, Borchers, Cowles, and some other investigators, we now possess a means for the artificial production of temperatures far above this limit, which enables us to fuse and otherwise treat commercially such hitherto refractory substances as chromium, platinum, carbon, and even the once indestructible crystalline form of that element, the diamond.

Generally speaking, electric furnaces may be divided under two main headings, namely, those in which the heating effect is produced by the electric arc established between two carbon or other electrodes connected with the source of current, commonly known as arc furnaces; and those in which the heating effect is produced by the passage of the current through a resistance, which either forms part and parcel of the furnace proper, or is constituted, by a suitable conducting train, of the material to be treated in the furnace. The principle of this latter type is analogous to that involved in the heating to incandescence of the ordinary electric lamp filament, and such furnaces are, as a class, known as resistance furnaces.

The earlier electric furnaces naturally assumed an experimental form, and, of these, that devised by Moissan, the celebrated chemist and investigator, is probably the simplest. It is an arc furnace, and consists of two chalk blocks, bored out at their centres to receive a carbon crucible which encloses the center or hearth of the furnace proper. Into this cavity pass two massive carbon electrodes, through openings provided for them in the walls of the structure, which is held together by massive clamps. Suitable terminal connections to the carbon rods are provided, exterior to the furnace, and the arc established between their inner extremities when the current is turned on plays over the centre of the crucible, heating its contents.

A furnace of this type, though its capacity is limited to a single charge of the crucible at each operation, has, nevertheless, proved itself of extreme utility in laboratory practice, and is a very efficient source of heat in that the hearth or centre of activity is entirely surrounded by refractory, non-conducting walls. Very little heat is consequently lost by diffusion or radiation.

A somewhat more elaborate modification of Moissan's original furnace has been devised by Messrs. Ducretet & Lejeune, of Paris, and is shown in Fig. 1. It consists of a refractory chamber *R*, built of fire-brick or some other suitable material, and provided with an opening *A* through which the substances to be treated may be introduced. *C C* are carbon rods, supported in massive tubular clamps *T T*, which are water-jacketed to keep down their temperature to a safe limit. *B* is a carbon or magnesia crucible, forming the hearth of the furnace, and containing a charge of the material to be treated, while *W* is a removable window, or inspection opening, fitted with ruby glass, through which operations requiring only moderate heat can be watched while in progress. When utilized for higher temperatures, this glass slide is replaced by a slab of refractory material, such as firebrick. The carbons *C C* project through the walls of the furnace, at right angles to each other, and the necessary separation of their inner extremities for the establishment of the arc takes place at a point just above the mouth of the crucible *B*, as shown. A system of tubes leads into the interior of the chamber *R*, and serves, when required, for the introduction of special gases, with which it may be necessary to cause the contents of the crucible to enter into chemical combination. A horseshoe permanent magnet *M*, manipulated at the exterior, exerts a repellant force upon the arc, directing it down into the crucible as desired, after the manner of a blow-pipe.

Sir William Siemens was the first to apply the electric arc furnace to commercial operations, and his apparatus and experiments were described in a paper read by him before the Society of Telegraph Engineers. According to this astute investigator, who seems to have, in a measure, grasped the conditions and general principles necessary to the successful operation of an arc furnace—no mean conception, when one considers the general lack of knowledge on the subject which prevailed at the time (over twenty years ago)—the advantages in favor of the electric furnace as a source of heat are that, theoretically, the heat obtainable is unlimited; fusion is effected in a perfectly neutral atmosphere; the op-

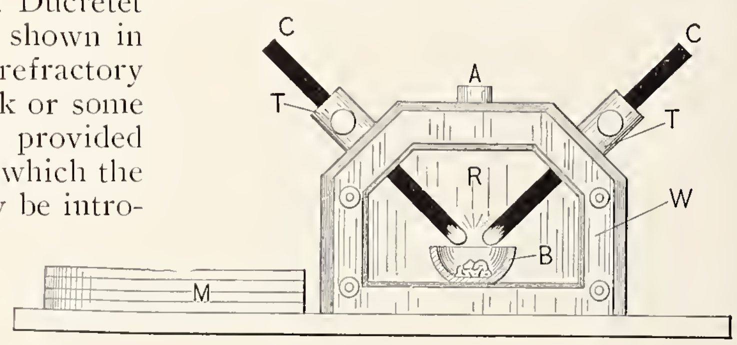


FIG. 1

eration can be carried on in a laboratory, without much preparation, and under the eye of the operator; and that the limit of heat practically obtainable with the use of ordinary refractory material is very high, because in the electric furnace the fusing material is at a higher temperature than the crucible; whereas, in ordinary fusion, the temperature of the crucible exceeds that of the material fused within it.

The general principle of the early Siemens arc furnace is represented in Fig. 2, in which *B* is a refractory crucible of plumbago, magnesia, lime, or other suitable material, which may be varied according to the nature of the substance to be dealt with. It is supported at the centre of a cylinder or jacket *J*, and is packed around with broken charcoal, or a similarly poor conductor of heat. Being thus isolated, as it were, from the surrounding atmosphere, it retains its heat, and very little is lost by diffusion. The negative electrode consists of a massive carbon rod *C* passing vertically through the centre of the lid of the crucible,

and free to move vertically therein, though the clearance opening is, for obvious reasons, very small. The rod C is suspended from the lower end of a copper strap S which conducts the

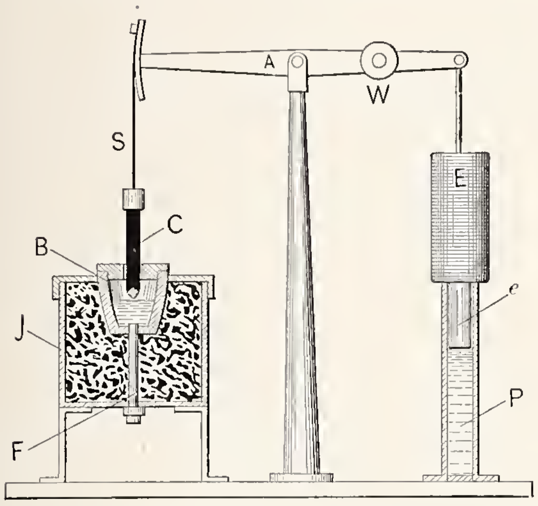


FIG. 2

current from it, being attached at its upper end to the curved extremity of a horizontal beam A. The other side of the beam is provided with an adjustable weight W, and carries, suspended from its extremity by a hinged joint, a hollow soft iron cylinder e, forming the core of the solenoid E. P is a dash-pot arrangement in which the cylinder works, the tendency of E being to raise it out of P against the counteracting force of the weight W, thus lowering the negative electrode into the crucible. The solenoid winding is connected as a shunt across the two electrodes. The positive electrode F, which may be of iron, platinum or carbon, consists of a rod of one or the other of these materials passing up through the centre of the base of the crucible. The furnace was originally designed by Siemens for the fusion of refractory metals and their ores; consequently, once the action is started, electrical contact is established between the lower electrode F and the semi-metallic mass in the crucible, and the arc continues to play between the surface of the mass and the movable carbon rod C. As the current through the furnace increases, that through the shunt winding of the solenoid diminishes, and the weight W coming into play, causes its end of the beam to descend, thereby raising the negative electrode C and restoring equilibrium.

The Willson furnace is essentially a modification of Siemens' original form, the solenoid regulation of the upper movable carbon being replaced by a worm and hand wheel, while the furnace is made continuous in operation by the provision of a tapping hole for drawing off the molten products. This type of furnace was employed in the manufacture of calcium carbide, which, when drawn off in a molten state, is much purer than the ingot or broken lump form, in which the greater bulk of that commodity is placed on the market.

The Parks carbide furnace, devised by W. P. Parks, of Chicago, is of the arc variety, and provides for the production of calcium carbide in the molten state. It is represented in Fig. 3, and consists of a vertical cylindrical structure F of refractory material, provided with a carbon hearth C, which, at the same time, acts as the negative electrode. It has an annular channel a cut in its upper surface, which latter is flush with the inner floor of F. This channel collects the molten carbide formed, and it drains down, to be ultimately drawn off at A. The upper positive electrode B consists of a massive, hollow carbon cylinder, in the lower half of which, or the portion inside the furnace F, are cut radial slots s s which subdivide the electrode and tend to set up a circle of arcs around the space bounded by the hearth. T T are gas supply pipes, ending in hydrocarbon burners inside of B, which primarily heat the raw material as it passes down the hollow centre of the electrode. The feeding is effected from

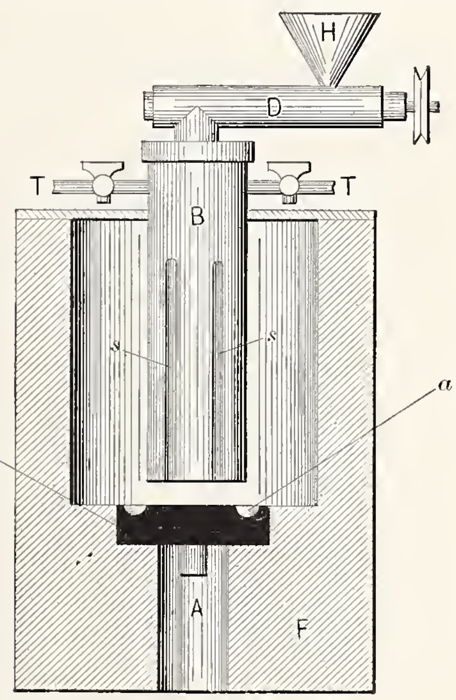


FIG. 3

a hopper H by an Archimedian screw working in the casing D.

An arc furnace, utilized in the production of aluminium from alumina, either *per se* or alloyed with other metals, is that utilized in what is known as the Herault process, carried on by the Swiss Metallurgical Company at Neuhausen. It consists of an outer iron casing or container F (Fig. 4) resting on an insulating base. This container is lined with massive carbon plates, cemented together with tar or suitable conducting material, and so arranged as to form at the centre a recess or hearth H, an outlet o, from the bottom leading out to the exterior of the furnace, and providing for drawing off the molten metal.

A series of copper pins c c driven into the iron walls of the container serve as a means of terminal connection to the carbon blocks, which constitute one electrode of the fur-

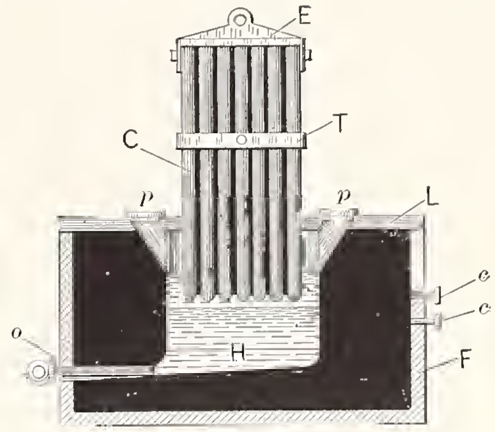


FIG. 4

nace, while the other, C, consists of a number of carbon plates, placed face to face, like the leaves of a book, the spaces between being filled in with some good electrical conductor, such as sheet copper. The composite electrode, thus built up, is mounted in a frame E, by means of which it can be raised or lowered as required, and terminal connection is secured by means of an encircling clamp T. The electrode C passes through a clearance opening in the lid L of the furnace, which consists of graphite plates; openings p p are also provided for the introduction of the raw material (alumina), thereby making the furnace continuous in operation.

The furnace is charged with alumina, as already indicated, and the electrode C having been lowered, the arc is struck. The heat thus set up fuses out the metallic aluminium, leaving the oxygen free to combine with the carbon of the electrode C, which it does, forming carbonic oxide gas. The molten metal collects at the bottom of the hearth and is drawn off through the outlet o, fresh alumina being fed in, and the height of the electrode C being regulated as the operation proceeds.

The King furnace is also of the arc variety, and is utilized in the manufacture of carbide in ingot form. It consists of a fire-brick chamber, through the roof of which passes vertically the upper, adjustable electrode. The lower, fixed electrode is carried by a small truck, or trolley, which runs along rails at the base of the structure, and acts the part of crucible or hearth. The lime and carbon are fed into it down lateral channels in the walls of the furnace, and are caused to combine by the heat of the arc set up. The upper electrode is gradually raised as the raw

material is fed in, until, at a certain point, the truck becomes filled with a block or mass of calcium carbide, and is then wheeled out of the furnace to discharge its load. While fusion is in progress a slight reciprocating motion is given to the truck, which serves to shake the charge well down and introduce fresh portions of it into the path of the arc proper. The Chavarria-Contardo arc furnace for the manufacture of calcium carbide possesses several novel points. Its general principle is represented diagrammatically in Fig. 5, where *e e* are the electrodes, running parallel to one another and slightly above the axis of the channel or trough *T*, which forms the hearth; *c c* are thin graphite plates, built up to form a roof-shaped structure, which becomes itself intensely hot when the furnace is active. The raw material is fed in at *A*, and, passing over the upper surfaces of *c c*, receives a preliminary heating of no mean degree; it then passes down, taking the course indicated by the dotted lines, under the electrodes *e e*, and into the trough *T*, where it is subjected to the most intense reflected heat of the arc. The moulten carbide formed is drawn off by way of the outlet *o*.

The disposal of the gases, especially carbon monoxide, resulting from the reactions in a carbide furnace has long been a stumbling-block to the manufacturer in that any attempt at modifying the furnace to this end resulted in

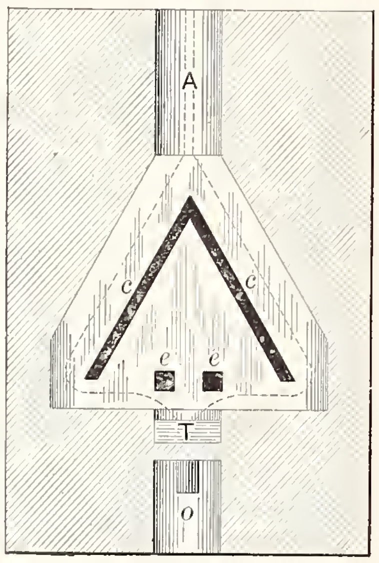


FIG. 5

undesirable complications and increased prime cost. This has been, in a measure, overcome in the Frolich arc furnace for carbide manufacture, invented by Dr. Osar Frolich, of Streglitz, Germany. The general arrangement is shown in Fig. 6, and consists of a cylindrical iron crucible *F*, mounted on standards *S*, and tapering at its base to a central discharge orifice.

A lining of fire-clay *L* protects the cylindricall wall, while the inner surface of the conical base is covered by the carbon electrode *C*. The remaining electrode consists of the massive carbon cylinder *B*, which is hollow, and depends, with its lower edge just over the discharge orifice, the arc taking

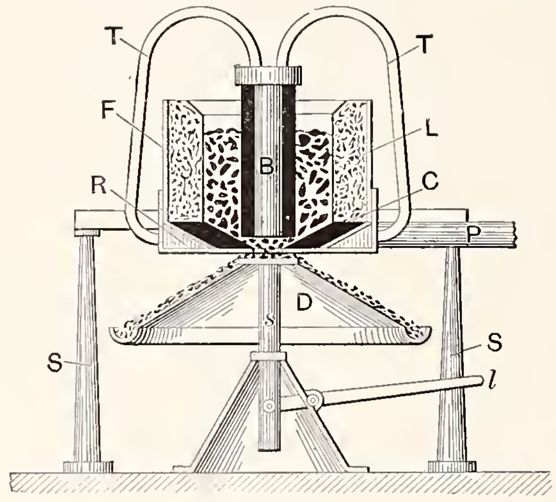


FIG. 6

place between the two edges of the carbons. Tubes *T T* lead from the upper portion of the carbon cylinder *B* to the annular chamber *R*, just outside and enclosing the space bounded by the lower electrode *C*. The gases of combustion pass up the centre of *B*, which acts as a flue, and down by way of the tubes *T T* to *R*, where they mingle with air, admitted through perforations in the casing, and are consumed, the final products passing out through the discharge pipe *P*.

The raw material is fed into the mouth of the furnace around the central electrode, and, passing through the annular arcing region at the bottom, where it becomes converted into carbide, falls onto the adjustable conical table *D*. This is provided with a lip around its lower edge, and is mounted on a stem *s*, which, gearing with the lever *l*, permits of its being raised or lowered, according as the operation of the furnace is intermittent or continuous.

The Denbergh furnace for the manufacture of sulphuric and phosphoric acids, and also "water-glass," or sodium ortho-silicate, is shown in Fig. 7. It consists of an ordinary firebrick structure *F*, lined at *r* with a refractory material impervious to the gases produced in the reactions, an outlet for which gases is provided at *o*. The body of the furnace is contracted below, as shown, and the outlet *R* for the fused products is led up within the walls themselves, from the point of lowest level to another point of higher level, which defines the depth of converted material contained within the furnace.

The lid *L* carries a charge inlet *i* and a hopper *H*, the feeding being secured mechanically by a reciprocating movement communicated to the piston *p*, which works in a cylinder *c*, carrying a definite quantity before it at each stroke. The electrodes *E E* are of carbon, passing through terminal sockets in which they are capable of motion in a direction corresponding with their axes, which permits of feeding as they wear away, while the sockets, in turn, are mounted in a species of swivel joint, which allows the angle of inclination, and consequently the height of the arc, to be varied at will.

Kroller's arc furnace is of a simple description. It consists of a longitudinal chamber, with massive carbon blocks projecting through the end walls. A series of carbon blocks, supported in line with the terminal electrodes, are arranged along the chamber at regular intervals, their number varying according to the voltage. The arc is thus split up into series, and a number of heated regions are secured in the centre of the mass of raw material which is packed around the blocks.

The Henriveux furnace, for the manufacture of glass, consists of three steps or slabs of refractory material, forming a species of cascade, the mixture to be fused being fed from a hopper onto the top step, whence it descends by gravity over the remainder. The heat from a powerful arc is directed upon each of the three steps, and the mass, in passing through the series of three, emerges finally in a molten state, and is collected in a suitable receptacle at the bottom where it is maintained in a state of fusion by a gas or coke fire. It is said to be a very wasteful process in that a considerable quantity of the heat devel-

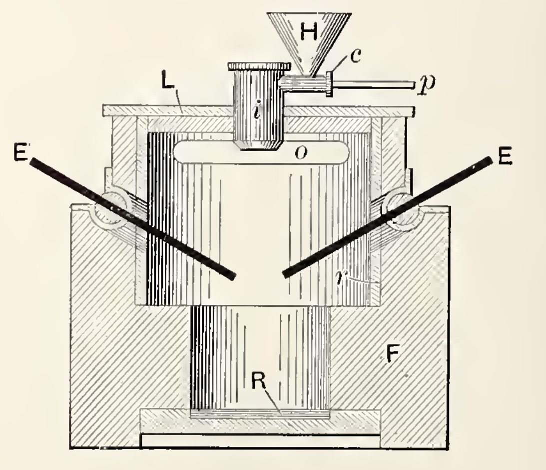


FIG. 7

oped in the arcs is lost or dissipated without performing useful work.

Passing now to resistance furnaces, Borchers' is typical of that class in which a core, forming part of the furnace itself, is heated by the passage of the current through it, and imparts its heat to the surrounding mass of material contained in the furnace. It is represented in Fig. 8, and consists of a block *B* of refractory material, through

the centre of which passes an opening *R* forming the crucible, or centre of activity, into which is fed the material to be treated. This space *R* is bridged by a thin carbon rod *c*, which is attached, at its extremities, to two massive carbon electrodes *C C*, passing through the walls of the furnace and fed with current through the large metal clamps *M*. These massive electrodes serve to conduct the current, without undue heating, to the smaller rod *c*, through which it passes, in turn, raising it to a very high temperature, owing to the resistance offered to its passage by a conductor of considerably smaller cross-section, and forming, as it were, a central, heated axis to the material contained in the crucible. It

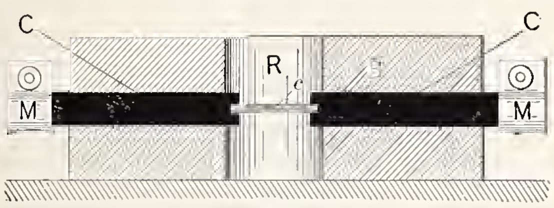


FIG. 8

thus diffuses its heat throughout the mass, from its centre outwards.

The Gibbs resistance furnace is based on the Borchers principle, a carbon rod, or rods, of small section being supported between massive carbon blocks set in cast-iron sockets let into the brickwork. The novelty of this invention, however, lies in the position of the small resistance rods. These are located above the furnace charge and do not come into actual contact with it at all, the heat being communicated by reflection from the domed roof.

The Acheson furnace for the manufacture of carborundum is a somewhat rudimentary device, in that it is built up and pulled down again for each charge of raw material dealt with. It is represented in diagram by Fig. 9, in which *F* is a rough firebrick structure, through the end walls of which project the electrodes *C C*, consisting of composite bundles of carbon rods set in massive metal clamps *M*.

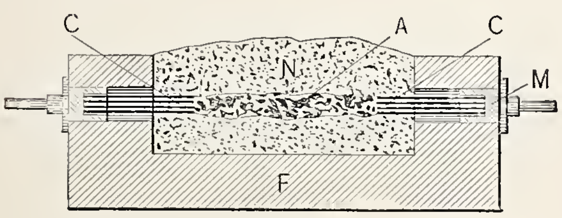


FIG. 9

The space between the two electrodes is bridged by a conducting path of coke *A*, which constitutes the distinct core of the furnace, and relegates it to the class of which Borchers' furnace is a typical example. This core is packed round with the raw material *N*, consisting of coke, sand, sawdust and common salt. The process of conversion is said to be far from economical.

A resistance furnace, based upon the fundamental principle of the Nernst lamp, has been devised by Drs. Nernst and Glaser. The resistance, or heater, is cylindrical, electrical connection with it at the top and bottom being secured by an annular packing of some conducting oxide, held in place by iron clamps and bolts. The hollow cylinder is surrounded by a jacket of oxide, loosely packed between it and an outer cylindrical sheath—an arrangement which prevents undue waste of heat. The heating cylinder, which consists of a mixture of magnesia, calcium carbonate, alumina, and silica, is closed by a lid, and the substance to be treated is either packed directly into it or contained in a crucible located within it. In the former case the cylinder is protected internally by an additional lining of pure magnesia, coated with graphite to give it an initial conductivity.

The Cowles furnace, again, is typical of that class of resistance furnace in which the path of high resistance consists of the material to be treated and does not form part of the furnace proper. The Cowles furnace first made its appearance in 1884, and takes several forms, all more or less similar in general principle, but differing in such general details as affect the class of work for which they are intended.

In its simplest form it consists of an oblong firebrick structure, provided with a lid, in which are one or more vent holes to permit the escape of the gases generated. Massive carbon electrodes are introduced horizontally through the two ends of the furnace, electrical connection with them being secured, in an early form, by a species of tubular gland through which each electrode passed, and which was filled with copper shot. In passing to and fro through these glands the carbon rods set up a kind of rolling friction with the shot, and fairly good electrical contact was thus established between them.

A preliminary lining of granular charcoal was given to the furnace, which, being a bad conductor of heat, prevented undue loss from radiation and diffusion. Inside this lining, again, was packed the partially conducting mass to be heated, forming a chain between the two carbon electrodes. When the current was turned on this mass became heated by the passage of the current through it, after the manner of the carbon filament in the ordinary incandescent lamp.

In a later form (Fig. 10) of the Cowles furnace charging funnels *F F* were introduced through apertures in the lid, whilst the hearth sloped from either end to the center, at the lowest point of which was provided an outlet *o* for drawing off the molten products. *C C* are the carbon electrodes; *G*, the glands containing the shot; and *c*, the lining of non-conducting charcoal. The funnels *F*, by a judicious feeding process, provided a means of keeping the resistance of the column of material fairly uniform at all points, thus ensuring an even distribution of heat throughout the mass.

The Cowles furnace for the treatment of zinc ores was also of the resistance type, and is represented by Fig. 11, where *R* is a long cylinder of fire-clay, mounted in a brickwork setting, and surrounded by a jacket of some refractory material *J* which is also a bad conductor of heat. The inner end of the cylinder *R* is effectually closed by a flanged disc of carbon *C*, which also constitutes one electrode of the furnace, the other taking the form of a plumbago crucible *P*, the convex base of which fits into the outer extremity of the cylinder *R* and forms a removable seal. Further, by way of an aperture *a* in the wall of the crucible, the metallic zinc passes over into

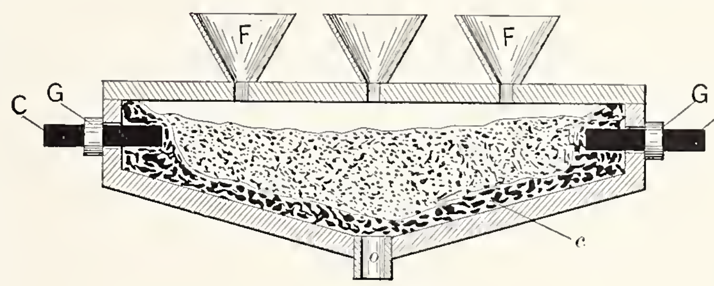


FIG. 10

it by distillation, and is collected therein, a chimney or outlet *c* serving to carry off the gases and fumes produced. The charge of broken zinc ore is, as before, spread evenly along the cylinder, so as to form a semi-conducting chain between the two electrodes.

The Cowles furnace for the manufacture of aluminium alloys partook

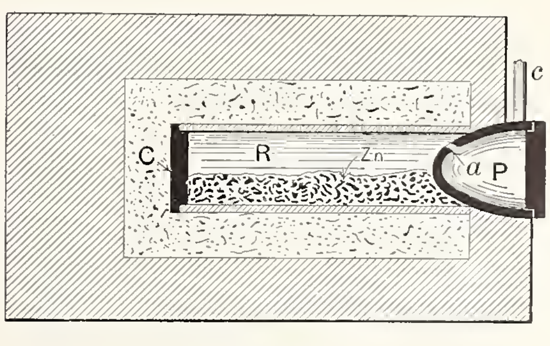


FIG. 11

of the nature of Borchers' furnace, although it had not, strictly speaking, a continuous resistance of its own. Two massive tubular electrodes, provided with a means for manual adjustment, carried close-fitting cores of smaller section, which inclined to one another and actually met, forming a conducting core of high resistance at

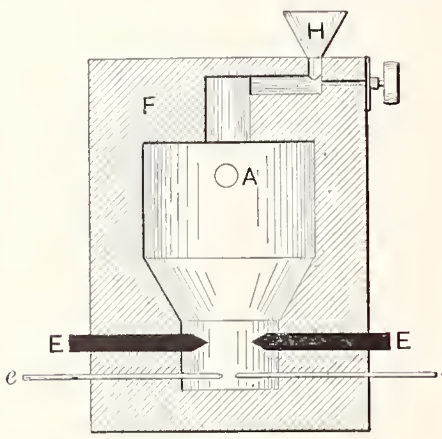


FIG. 12

a point in the centre of the furnace, immediately under the aperture of the feeding hopper. These smaller electrodes, together with the raw material fed on to them at the point of meeting, formed a conducting link of high resistance between the main electrodes, and the heating effect of the current was thus localized and confined to the point at which it was most needed, namely, at the feeding centre of the cavity.

A circular form of resistance furnace, devised by M. R. Conley, and intended mainly for the reduction of iron ores or the manufacture of steel, consists of a cylindrical firebrick structure, the inner wall of which is contracted to form a narrow opening at about two-thirds of its depth to the hearth proper, which lies below. At the contraction is introduced a circular set of electrodes of segmental form, made of the usual compressed carbon mixture, and isolated from one another by intervening segments or pillars of firebrick.

The electrode segments constitute an even number, and are connected alternately to the positive and negative poles of the source of current. Means of adjustment are provided which allow the segments to be fed radially as they wear away. A similar circle of segmental electrodes surrounds the central portion of the furnace proper, on a crucible, which is located below the contraction and provided with an outlet for drawing off the molten metal as it forms. By a suitable manipulation of the current and connections to the furnace, it is possible with this device to secure a combination of heated zones or paths through the mass of material under treatment, the position of which can be varied at will, so as to penetrate to all parts and secure a homogeneous and uniform fusion.

The Readman-Parker furnace for the manufacture of phosphorus was invented independently by these two gentlemen in 1888, and they subsequently combined their ideas to form a community of interests. It consists of the usual firebrick structure *F*, Fig. 12, and feeding hopper *H*, the furnace being hermetically sealed, in order to exclude atmospheric air. A discharge flue *A* carries off the gases and vapors formed during the process, and the interior of the chamber is contracted at its lower portion, as shown, to form a hearth. Multiple electrodes *E E* are employed facing one another in two rows, passing through the side walls of the structure, while smaller electrodes *e e*, below them, which can be brought into closer proximity, are employed to start the current flow. These are subsequently withdrawn, and the action, which resembles that of a resistance furnace with a conducting path formed of the material under treatment, is maintained between the main electrodes *E E*.

The ingot carbide furnace recently patented by Mr. Parker should have a decided future before it. The principle of its construction is represented in section plan in Fig. 13, in which *R* is a cylindrical retort or crucible, lined throughout with carbon *C*, forming one electrode, the other being a massive carbon block of rectangular section *B*, which is supported at the centre of the retort, and is of such dimensions that its corners approach very closely to the inner carbon walls of that vessel. The raw material is fed in at hoppers on either side of *B*, their position being indicated by the circles *a* and *b*. While working, the crucible and its contents revolve, thus constantly bringing fresh portions of the

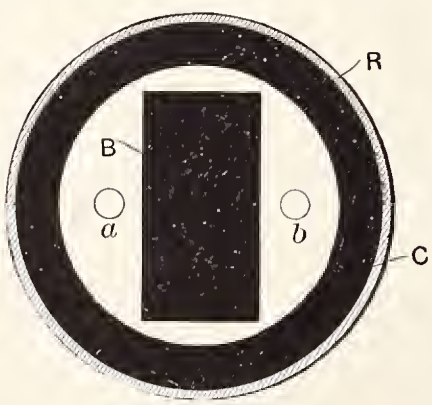


FIG. 13

mass within the zone of activity, while by a carefully proportioned train of gearing the electrode *B* is gradually raised at such a rate that its lower extremity is always immersed at a constant depth in the mass under treatment, while an ingot of finished carbide is gradually built up beneath it in the crucible.

A series of patents have been recently granted in the United States on electric furnaces for the manufacture of such comminuted products as pigments, abrasives, oxides, refined metals, and a miscellaneous collection of similar character. The general arrangement consists of an arc, or resistance, furnace, with which is combined an air blast device, playing either immediately onto the furnace contents or upon the vapors rising from it. An example will serve to demonstrate the general principle involved.

Fig. 14 represents a furnace of this description, devised by C. S. Lomax, and patented as recently as March, 1902. It is intended for the manufacture of the various commercial oxides of lead and tin. A refractory block *F* has a narrow channel *c* cut in its upper surface; this constitutes the hearth of the furnace, and is of uniform cross-section for about the centre third of its length. At each extremity it merges into a deeper and wider wedge-shaped cavity, in either of which is placed, vertically, an electrode; *T* is a main, supplying cold or

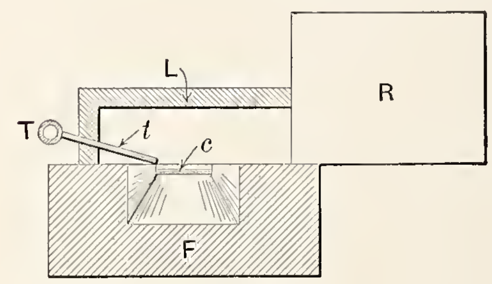


FIG. 14

heated air to the discharge jets *t t*, which are set at such an angle that the air emerging from them is projected downwards into the central trough or channel; *L* is a cover or screen, which collects the products and guides them into the chamber *R*.

The mode of procedure is exceedingly simple. The channel *c*, together with its enlarged ends, is filled with the molten lead or tin to be converted; the current is turned on, and that portion of the molten column, bounded by the narrow central channel, immediately attains a considerable temperature, owing to its smaller cross-section. When the required heat has been reached the air blast is brought into play, causing the finely divided metallic particles to combine with its oxygen, the resulting compound being carried over into the chamber *R*. This form of furnace is adaptable to making a variety of oxides, the necessary changes in chemical combination being brought about by varying the respec-

tive temperatures of the air blast and the molten metal.

Ruthenburg's electro-magnetic furnace is another practical example of the proverb "Necessity is the mother of invention." One of the purest sources for the extraction of metallic iron is "iron-sand" and similar ores, the process of treating which has hitherto been hampered by their finely divided state and consequent clogging of the smelting furnaces. Ruthenburg's invention has in view the preliminary agglomeration of this sand, with the object of thus converting it into a form more suitable for the ordinary operation of smelting.

His furnace is represented in Fig. 15, and consists of two similar cast-iron hoppers *H H* hinged together at the point of support *a*, and into which the iron-sand is fed at equal rates. The discharge orifices *o o* are opposite to each other, and the distance between them can be varied at will by the hand-wheel and worm *W*. The two hoppers constitute the electrodes, terminal connection with them being secured as shown at *t t*, where the discharge nozzles are also water-jacketed; *C C* are magnetizing coils, encircling the hoppers, and having their windings connected either in series with, or in shunt across, the hoppers. Their office is to magnetize the individual particles of the sand causing them to adhere to-

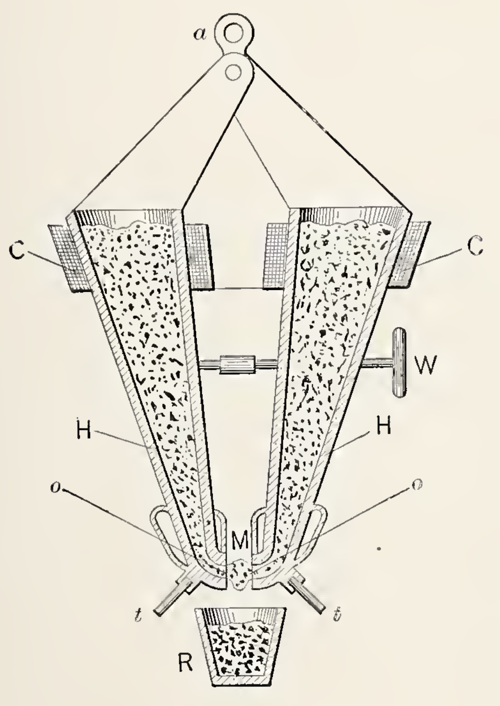


FIG. 15

gether temporarily and thus assist in forming a self-supporting mass *M* across the discharge apertures. This mass is subjected to the maximum heating effect, and the semi-molten product drops away into the crucible *R* placed to receive it.

A novel type of resistance furnace, patented independently, with some slight variation of detail, by Colby, Ferranti, and Kjellin, is worked on the inductive principle, and consists of an annular, or helical, channel in a refractory base, filled with a conducting, or semi-conducting, medium, which constitutes the furnace charge, and has a heavy current induced in it by a surrounding coil of many turns, carrying an alternating current. The device, in point of fact, acts as the closed-circuit secondary of a step-down transformer, and is said to be admirably adapted for the fusing of such metals as platinum, which, if exposed to the atmosphere during the process, as in the ordinary type of furnace, occlude oxygen and other gases in their mass, which lead subsequently to blow-holes and other imperfections in the casting.

The experience of late years in the construction and use of electric furnaces trends toward the establishment of the resistance furnace as a type more readily capable of efficient regulation. This is further accentuated by the fact that overheating is, to a considerable extent, possible, and indeed prevalent, in many types of furnace, especially those of the arc variety. Scientists and others, unversed in the possibilities of the electric furnace as a source of artificial heat, hailed its introduction with delight as a means of overcoming many of the difficulties previously imposed by the limitations of temperature. In so doing, they in many cases overlooked the very simple fact that it is possible to have too much of a good thing, and the consequent tendency was to overrate rather than underrate the temperature required for various commercial processes.

Experience, however, has exposed this fallacy, and, as a natural result, we turn to that type of furnace which offers the best means of regulation and the absence of excessive variation, viz., the resistance furnace. Here again we are beset with further difficulties, for, if we employ a portion of the charge itself as a high-resistance column, excessive variations creep in, owing to the changeable nature of the column with the reactions taking place within it, whereas, if we employ a definite core of small cross-section, as in the Borchers class, the capacity of the furnace is limited, and the cost of its upkeep is increased by the very necessary and frequent renewal of the conducting-rods.

With a view to minimizing these various drawbacks, Mr. H. I. Irvine, of Niagara Falls, has brought out a resistance furnace in which the heated column consists of a fused electrolyte, maintained in a state of fusion by the passage of the current, and communicating its heat by radiation and diffusion, to the encircling charge, which is packed around it.

The general construction of this furnace, which was mainly designed for the manufacture of phosphorus, is represented in Fig. 16. It consists of a refractory structure *F* lined with carbon *C* and fitted with a domed roof *R*, in the centre of which is a hopper *H*. Two vertical carbon electrodes *B B* descend vertically through *R* to within a short distance of the hearth, while a possible variation in the direction of the heating effect is provided by lateral electrodes *b b* connected with the hearth itself. The action of the furnace is first started through a mass of

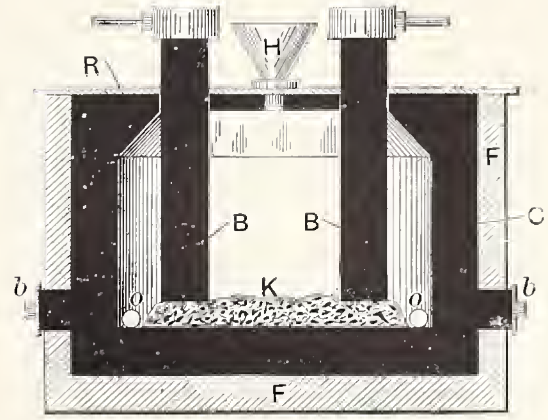


FIG. 16

coke *K*, which forms a bridge between the electrodes *B B*, and is subsequently maintained by the fused slag from the furnace charge, which flows down between the electrodes and is maintained at constant level by the overflow outlets *o o*.

As pointed out by Mr. Carl Hering, the firebrick or other refractory lining of all furnaces, when heated, becomes a conductor, after the manner of a Nernst lamp glower. Though unavoidable, this is a contingency which, with furnaces of the resistance type, at least, must be taken into account, in that it increases the total conductivity of the device and necessitates a corresponding increase in the working current. He further points out that the heat thus communicated is not lost, except in a small degree, consequent upon the decrease in the thickness of the non-conducting walls and the diminution of their heat conserving qualities.

Equally important with the selection of an easily regulated and comparatively invariable electric furnace ranks the question of temperature determination. At the enormous temperatures developed in the electric furnace all previously known methods of temperature measurement, whether by thermometer or pyrometer, desert us, in that the constituent parts of these various apparatuses will not stand the direct application of such terrific heat. Here, again, stern necessity has been the means of inspiring investigators to action, with a view to discovering some efficient method for the measure-

ment or comparison of these high temperatures.

Fery's suggested method for determining the high temperatures usually encountered in electric furnaces consists in a practical application of Stefan's law, which is to the effect that the radiation of an absolutely black body is proportional to the fourth power of its absolute temperature. Kirchoff has proved that the interior of an enclosure of which the walls are at a uniform temperature is equivalent to an "absolutely black body," *i. e.,* a body which absorbs all the heat imparted to it, giving it out again by radiation, and not by reflection. In this connection, therefore, the interior wall of an electric or other enclosed furnace may be regarded as an absolutely black body, a small aperture in which does not materially affect the conditions governing this definition.

Fery's practical application of this law to the measurement of furnace temperatures consists in a species of telescope, with a fluorspar objective; this telescope is placed in line with the aperture in the furnace wall, and, receiving the heat radiated therefrom, concentrates it upon a small thermo-couple. By an inner diaphragm, regulating the number of rays which reach the thermo-couple, the device is rendered independent of its distance from the furnace wall. The fluorspar objective, by its absorption of radiant heat, reduces the sensitiveness of the arrangement by about 10 per cent.; but, notwithstanding this, it has proved of extreme utility, owing to its enormous range, and its applicability in such cases as those with which we are dealing at the present moment, where other generally accepted methods are out of the question. The actual temperature is, of course, obtained from a specially prepared table or curve and is read from the electro-motive force recorded by the thermo-couple.

Another, somewhat crude, method of measuring furnace temperatures, into which the personal element is liable to enter, causing an error of judgment, consists in a telescope, as before, mounted on a convenient stand, and placed in line with a small aperture in the furnace wall. Inside the tube of the telescope is located a small incandescent lamp, which can be energized by one or two battery cells, and the current through it, and an ammeter placed in series with it, regulated by a suitable switch and rheostat. The principle upon which its action depends is that which involves the apparent disappearance of the filament, when raised to the same degree of incandescence as the furnace lining and viewed against the latter as a background. If the lamp be inactive, the filament appears as a black line; at equal incandescence it becomes invisible, while if its state of incandescence be above that of the furnace, it assumes the appearance of a white line. By regulating, therefore, the current through the lamp until the filament apparently disappears, its temperature is made equivalent to that of the furnace, and the result is read on a specially prepared table. The limit of the apparatus is 3600 degrees Fahrenheit, so that for electric furnace work its field of utility is somewhat limited.

In the preceding paragraphs the writer has by no means covered the entire field of development of the electric furnace, but has confined himself to a brief description of those examples which serve as a general type of the class to which they respectively belong. The subject is a large one, and its comprehensive study would fill a volume of no mean dimensions, while its importance, from a chemical and metallurgical point of view, must not be underrated.

At the end of the year 1900 the power used in electric furnaces was estimated at 225,000 H. P., of which 185,000 H. P. were employed in the manufacture of calcium carbide, 27,000 H. P. in the manufacture of aluminium, 11,000 H. P. in that of copper, while carborundum was responsible for the output of some 2000 H. P. Any gain, therefore, in the construction or working of electric furnaces, however slight, or apparently worthless, provides food for serious reflection, in that it may be the means of saving large sums of money annually.

The German Federal Telephone System

UNITED STATES Consul-General Richard Guenther, at Frankfort, Germany, reports that the total cost of the German federal telephone system, operated in connection with the German federal telegraph system, is $60,000,000 up to date. The kingdoms of Bavaria and Wurtemburg are not included, these having their own independent telephone systems.

The longest telephone connection in Germany is the one between Berlin and Paris, 742 miles. Next is Berlin and Budapest, 612 miles; Berlin and Memel, 593 miles; Berlin and Basel, 577 miles. The following connections are all more than 300 miles long: Berlin with Dortmund, Düsseldorf, Essen, Frankfort, Gleiwitz, Cologne, Konigsberg, Munich and Vienna; Hamburg with Copenhagen; Frankfort with Paris and Hamburg.

The line between Berlin and Frankfort is the most used—485 communications daily. The number between Berlin and Cologne is 243; Berlin and Vienna, 118; Berlin and Düsseldorf, 116. In spite of the high fee not less than sixty-five communications daily take place between Berlin and Paris.

Wireless Telegraphy in Africa

SPACE telegraphy is said to be proving of value to the German authorities in Southwest Africa. At the beginning of the insurrection of the natives, the military telegraph lines, which were the only means of connection between the field and headquarters, were continually being cut down and destroyed. During the last few months, however, every detachment of troops in the field has been provided with wireless instruments, it is said, and has been in constant communication with the commander-in-chief. Because of this success the German War Department is reported to have decided to establish a new army branch of expert space-telegraph operators under the command of a high officer of the general staff.

Electric Railways in New Jersey

THE State Board of Assessors of New Jersey has issued a supplemental report which shows that there are seventy electric railway lines in the State. Their gross receipts last year amounted to $9,574,552; expenditures, $5,881,046; dividends paid, $630,150. These figures compare with the previous year as follows:—Gross receipts, increase, $680,298; expenditures, increase, $789,755; dividends, increase, $89,510. The total mileage of the lines is 980.56 miles; capital stock, $85,061,880; bonded debt, $67,747,000; other debts, $7,362,968. The estimated cost of roads and equipment is $160,344,176.

The danger from electricity, particularly for firemen in directing a stream of water upon an object carrying electric current, was the subject of an article in a recent issue of "Energie," of Berlin, recording the results of a number of tests. A man wearing wet shoes and standing on a wet plank flooring threw a jet of water on an electrified plate. At 500 volts and an aperture of 0.74 inch in the nozzle he felt the current at a distance of 2¾ feet, and with an aperture of about 2 inches could not get nearer than about 3¼ feet. Under the same conditions, but with alternating current, he could not stay within 8.2 feet, and at 3,600 volts he had to remain at a distance of 26¼ feet.

Reverse Current Circuit Breakers

By WILLIAM M. SCOTT

A "REVERSE current" circuit breaker, or, as it is sometimes very aptly called, a "discriminating cut-out," is a circuit breaker which automatically severs the circuit in the event of the flow of current being abnormal in direction, and which, unless interrupted, would result in misapplication of energy. The reverse current circuit breaker most perfectly adapted to the requirements of engineering practice is one which is dependent for its operation solely upon the occurrence of reverse current flow. It is desirable also that loss of voltage shall not cause the operating of the reverse current circuit breaker, and it should be so constructed that it can be closed upon open circuit.

In order to meet the varying conditions which may arise in the use of the circuit breaker, the volume of reverse current necessary for its actuation should be subject to convenient adjustment. The operation of the circuit breaker should be independent of voltage variations throughout the normal working range, and should be positive at all voltages to which it is liable. The force tending to cause the opening of the circuit breaker upon reversal should increase with the volume of the reverse current. In these last respects, particularly, many of the reverse current devices on the market are conspicuously defective. Considering, as an instance, those which depend for their opening force upon a tripping coil which, when brought into circuit by means of a polarized relay actuated by a reversal of the current, is energized by the voltage of the system, it will be seen that where the reversal reaches the magnitude of a short-circuit, the voltage of the system may be reduced to but a fraction of its normal value, and the tripping coil may, as a result, be insufficiently energized to effect the opening of the circuit breaker. Where, in order to avoid this very evident cause of failure, the tripping coil is connected in an independent circuit, new complications are introduced without corresponding advantage.

Obviously the operation of any safety device should depend entirely upon the conditions prevailing in the circuit to be protected, and its effectiveness should not be determined or limited by the condition of some independent circuit or appliance, the failure or disconnection of which may render the safety device inoperative at the critical moment. The following is a description of a circuit breaker, in the operation of which all of the foregoing requirements are fully met:—

In Fig. 1 it will be seen that the reversal feature of this circuit breaker is secured by the co-operation of two electro-magnet systems; one consists of a pivoted core and pole pieces depending for excitation upon a coil connected in the main circuit; the second consists of two independent cores, parallel with the first and excited in sympathy with each other by two magnetizing coils which are subject to the full voltage of the circuit. The pole pieces of the series magnet normally stand just midway between the polar extensions of the cores of the shunt-wound system. In the exciting coils of these two systems are so related that during the flow of current in the direct sense the movable pole pieces are held in their medial position by the attraction of

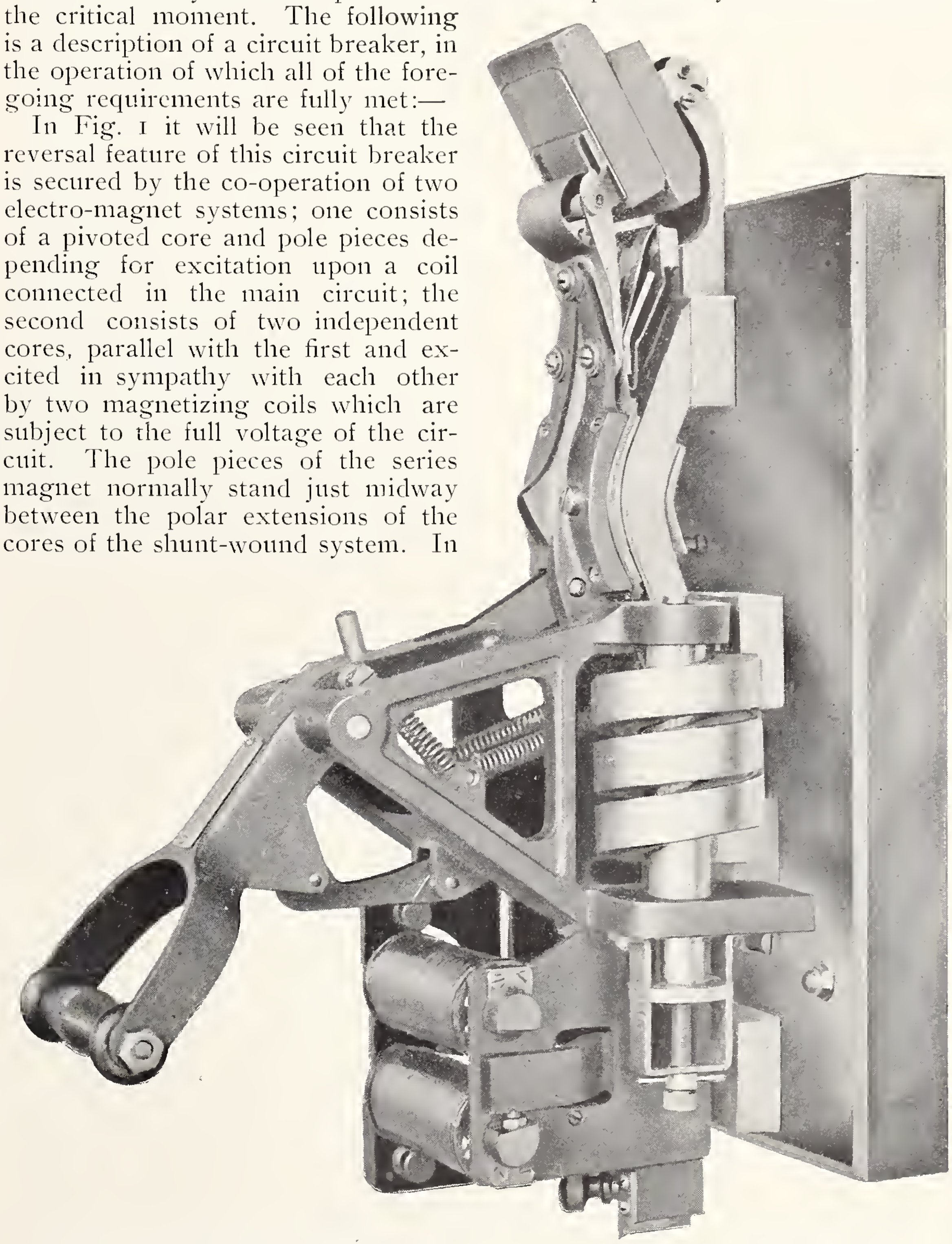


FIG. 1.—AN OVERLOAD AND REVERSE CURRENT CIRCUIT BREAKER, MADE BY THE CUTTER COMPANY, PHILADELPHIA

this position they are supported from below by suitable stops. They are free, however, to move upward into engagements with the upper core, and in so doing cause the release of the latch restraining the switch.

The windings and connections of the lower core acting in addition to the effect of gravity, while upon a reverse current flow the pole pieces are drawn upward in opposition to gravitation into engagement with the upper core, these opposite reactions being due to the fact that the magnetism

induced by the shunt coils is not subject to change in direction upon a reversal in the main circuit. Upon direct current flow, therefore, the series magnetism compounds with that of the lower shunt magnet, while upon reverse flow it compounds with that of the upper one.

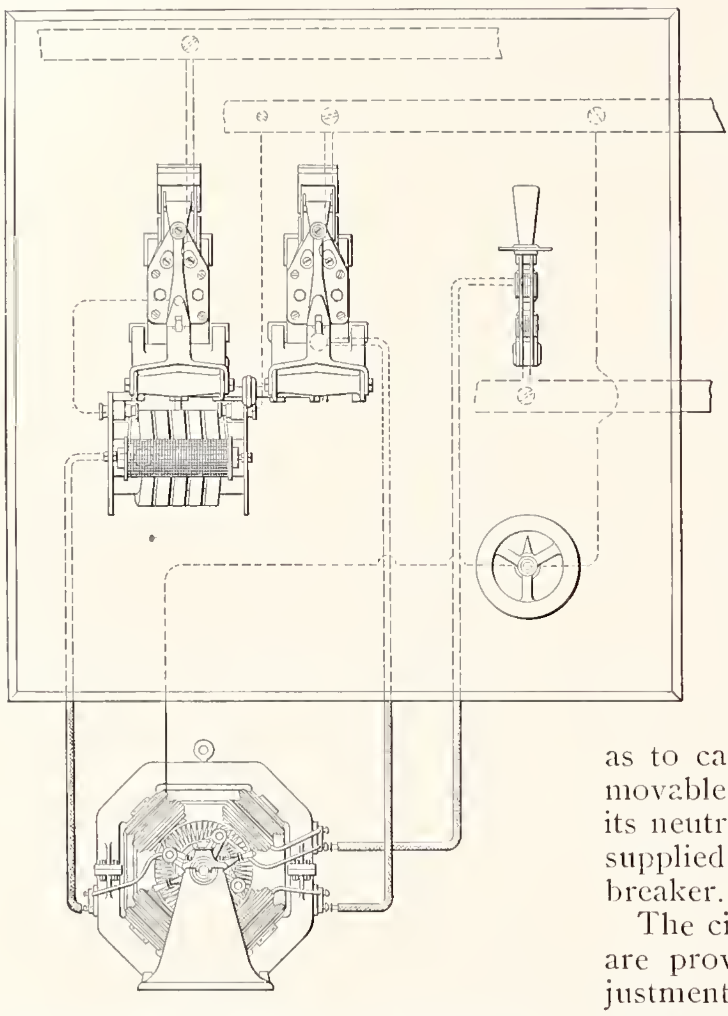


FIG. 2.—CONNECTIONS OF CIRCUIT BREAKER FOR PROTECTING GENERATOR OPERATING IN MULTIPLE

It will thus be seen that the operation of the circuit breaker is dependent upon the co-operation of voltage and current. Although on account of the location of the movable pole pieces midway between the shunt excited cores, the voltage alone will not cause the operation of the circuit breaker, nevertheless, at and considerably below normal voltage, the shunt excitation provides quite sufficient power for this purpose, when made effective by placing the movable pole pieces above their neutral position; but upon reversal, the magnetism due to the flow of reverse current supplements that of the shunt excited core toward which the movable pole pieces are attracted. The effect of this in insuring positiveness in the operation of the circuit breaker may be best understood by an inspection of Fig. 3, illustrating the performance of a 600-ampere circuit breaker of this type, designed for the protection of a 500-volt generator operating in multiple with others similarly protected.

The ordinates of these curves correspond with the various voltages upon which the circuit breaker is tested; the abscissæ, with the corresponding reverse currents required for the operation of the circuit breaker and consequent opening of the circuit. The three curves coincide respectively with 8, 20 and 75 amperes adjustments, which are correct at 500 volts pressure. It will be noticed that for variations of 100 volts either way from normal the performance of the instrument corresponds closely with the calibrations, and that as the voltage of the circuit falls the value of reverse current necessary for the operation of the instrument continues to increase; but within the limits of the test, which was carried down to 30 volts, the operation of the instrument was uniformly reliable and positive. When at any voltage the reverse current had reached such a value as to cause the initial motion of the movable magnetic system away from its neutral position ample energy was supplied for the tripping of the circuit breaker.

The circuit breakers here described are provided with a convenient adjustment determining the value of the current upon which they will operate. This adjustment is obtained by the movement of a counter-balance along a calibration plate, the scale being long and easily read. The normal range of adjustment is from 5 per cent. of the normal capacity of the circuit breaker to 25 per cent., but any other specifications can be met.

The principles of these circuit breakers are such as lend themselves with suitable modifications to designs for alternating - current service. Where alternating-current work is considered instead of direct, the necessarily high inductance of the shunt coils of the reversal feature introduces an entirely new and highly important factor. By means, however, of designs which have been the result of much careful research and experiment, this and other difficulties have been overcome, and the engineer now has at his disposal for alternating-current service, as well as for direct, a reverse current circuit breaker which will fully meet the most exacting requirements.

The design of the alternating reverse current feature is such that on a circuit of ordinary power factor, the magnetism due to the shunt coils during normal conditions is approximately in phase with that due to the line current. The reactions between the two magnetic systems of the reversal feature are determined not only by the magnitude of the current, but by its phase relation to the E. M. F. The reverse current may be considered as made up of two components, one in phase with the E. M. F., representing the reverse energy flow, and a second lagging 90 degrees behind the E. M. F., representing a wattless flow. The construction of the reversal feature is such that it responds only to the first named component, the wattless currents having no appreciable effect on its operation. For this reason the calibrations are marked in units of power, not in units of current, and indicate, therefore, the energy reversal which will cause the opening of the circuit breaker. It will be seen that these indications can be checked by ammeter readings only when the phase of the current and the

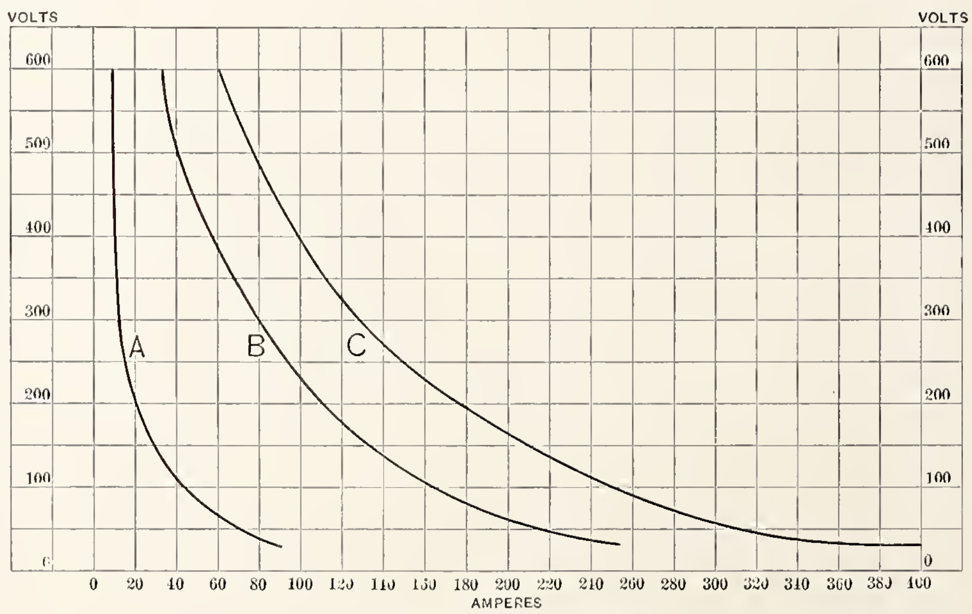


FIG. 3.—CALIBRATION CURVES FOR 600 AMPERES, 500 VOLTS. "REVERSITE" CIRCUIT BREAKER

voltage of the system are also taken into consideration.

THE PROTECTION OF GENERATORS

So long as generators are operated singly, their protection is fully insured by the use of simple overload circuit breakers. When, however, generators are operated in multiple, new conditions are introduced which require protective appliances having features not found in the simple overload circuit breakers. Where generators are run in this manner, in case of accident to one of them or to its prime mover, not only will this unit cease to deliver its quotum of current to the external circuit, but the other units in parallel with the damaged one will begin to force current into it. The normal generators will, therefore, supply not only an undue share of the effective load, but also additional current delivered to the crippled unit, resulting in unnecessary overloading of the normal generators and a possibility of injury to the crippled one.

The use of simple "overload" circuit breakers, would, in such a contingency, result in cutting out the disaffected generators as well as the crippled one, with the result that, momentarily at least, the service would be interfered with. It is evident that the protective device for the generators should be of such a character that the crippled unit shall be automatically disconnected before it shall have taxed the others. Thus the load will at once devolve upon the normal units without even a momentary interruption of the current supply. The device here described adequately meets these requirements. Where each generator of the system is protected with it, crippled units will be immediately disconnected.

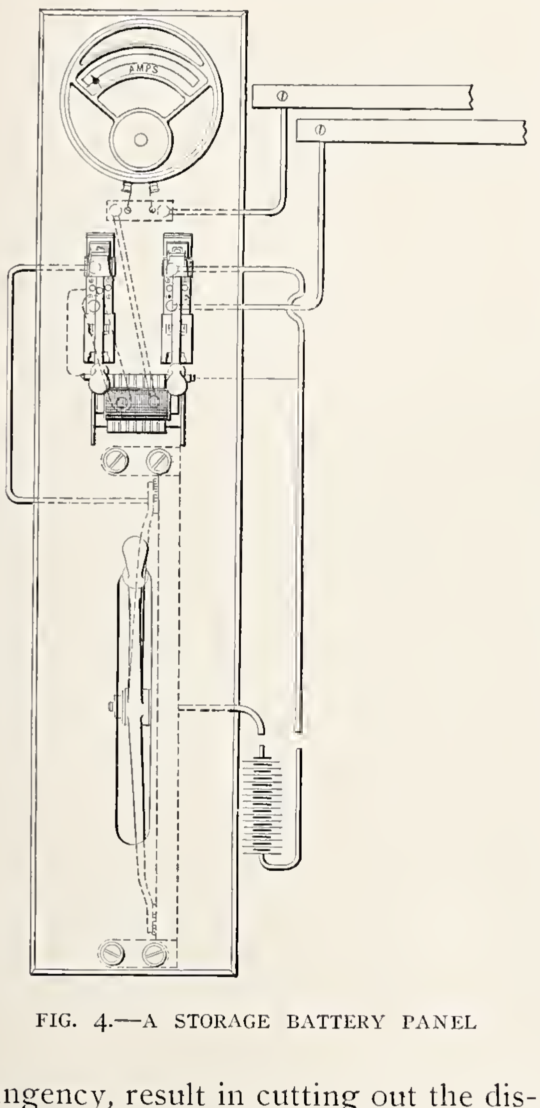


FIG. 4.—A STORAGE BATTERY PANEL

The protection afforded by these circuit breakers is of especial value in power plants, the demands upon which are such that reserve units must frequently be thrown into service. Such a requirement is often of the nature of an emergency, and it is of the utmost importance, therefore, that the necessary connections shall be made promptly. If, however, the engineer connects the reserve unit to the bus-bars an instant too soon, in the absence of proper protective devices, the current reverses into it and thus adds to the load upon the other generators. Where each generator is protected with a reverse circuit breaker of the kind here described no unit can be effectively thrown into parallel with the others until it is up to the voltage. The use of this type of circuit breaker gives the engineer confidence, saves delay and affords the generator complete protection.

The circuit breakers have also an incidental value, in that they serve to automatically disconnect each generator as its prime mover is slowed down when the generator is being taken out of service, as the instant the slowing-down results in a drop in voltage of the generator a reversal takes place which opens the circuit breaker.

The method of connecting the circuit breakers for the protection of generators operating in multiple is shown in Fig. 2. The two poles of the circuit breaker are introduced in the usual manner into the circuits of the generator leads; the shunt coil is then connected so as to receive full line pressure. One terminal of the coil is to be attached to the small spring contact located back of the left-hand switch member of the circuit breaker; the other terminal must connect with the bus-bar of opposite polarity. The actual passage of current from the generator is perhaps the best method of ascertaining whether the shunt coil has been connected so as to make the circuit breaker operative upon reversal. If, upon trial, the reversal feature responds to current flowing in the direct sense, the connections of the shunt coil should be reversed.

Alternating-current generators operating in parallel are subject no less than are direct-current generators to reversals of current. Some idea of the correctness of this statement may be gathered by an inspection of the ammeters on the switchboard in any alternating-current plant. Obviously, the total current delivered to the bus-bars by a number of generators in multiple should closely approximate the total current delivered from the bus-bars to the external circuit The excess of the former as compared with the latter is a measure of the current passing between generators and thus diverted from the external circuit.

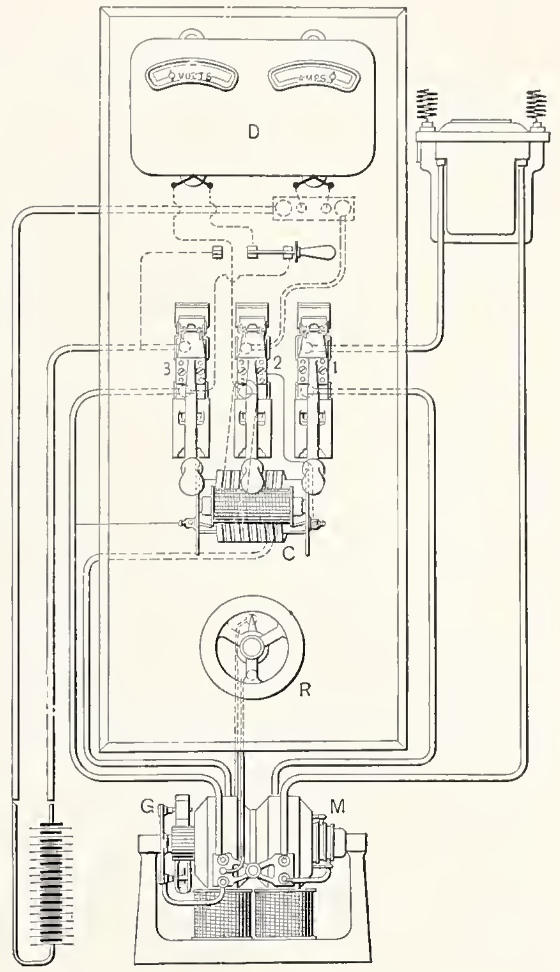


FIG. 5.—ANOTHER FORM OF STORAGE BATTERY PANEL

To many engineers in charge of alternating-current plants, the operations of the alternating-current are filled with mystery, and they are, therefore, inclined to accept the guarantee of manufacturers of the generating apparatus of which they are in charge, rather than to reckon with the obvious facts of the case. The protection of alternating-current generators with the here discussed reverse circuit breakers places a check upon the operation of these generators and will enable the engineer, by suitable adjustments of generators and prime movers, to get the best possible performance from them, or to locate such apparatus as is hopelessly at fault in this respect.

THE PROTECTION OF ROTARY CONVERTERS

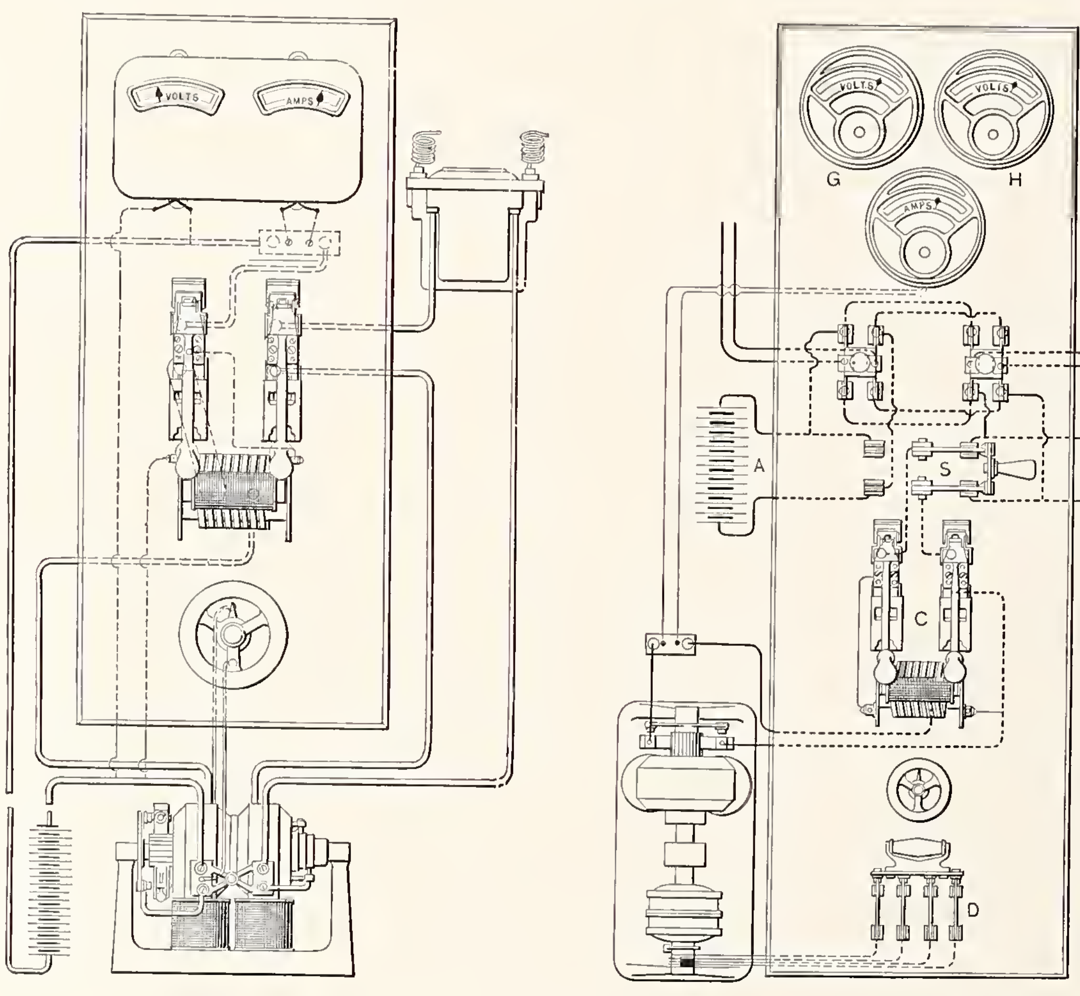
The operation of rotary converters in parallel is analogous to that of other generating apparatus, and cor-

responding conditions may readily arise, causing one or more rotaries so connected to operate in the reverse sense; that is, taking current from the direct-current side and delivering power to the alternating-current mains. Where the rotaries are protected by proper reverse circuit breakers, such tendencies are arrested in their incipient stages. The reversal feature of the circuit breaker may most conveniently be installed in the direct-current side, the switches of the breaker controlling either the direct or alternating-current side, or both, as the requirements of the installation may demand.

Where rotaries are started from the direct-current system, the reverse current breaker, in order to conveniently permit the passage of the starting current, may be made inoperative during the starting period by opening the circuit of the shunt coils of the reversal feature. This is most readily accomplished by means of a small switch in the shunt coil circuit, interlocked with the line switch of the rotary on the alternating-current side, so that the shunt coils will receive current only when the rotary is connected with the alternating-current mains.

THE PROTECTION OF TRANSMISSION LINE IN MULTIPLE

Where power is delivered to a single receiving point by more than one system of feeders, it will be seen that in the absence of suitable protective devices properly disposed, a short-circuit upon one set of feeders will be fed not only through the portion of the feeder located between the short-circuit and the source of supply, but also by means of the portion of the damaged feeder beyond the short-circuit, with current flowing in the reverse sense from the receiving station. Overload circuit breakers at both generating and receiving ends of the cables form a means of isolating the damaged lines. Their use alone, however, is liable to cause momentary interruption of service in the uninjured cables, which will be repeated until the damaged line is finally located and put out of service. Circuit breakers having reverse current operation, located at the receiving end of the transmission lines, will automatically sever the damaged cables at this end and prevent the receiving station from feeding back into the short-circuit, this being attained without even momentary interruption of the service. These considerations have equal importance in both direct-current and alternating-current practice, with perhaps a wider scope of application in the latter field. In combination with overload circuit breakers at the generating end of the feeders reverse circuit breakers at the receiving end should give adequate protection under all conditions of service which are likely to arise.



FIGS. 6 AND 7.—STILL OTHER STORAGE BATTERY PANEL METHODS

THE PROTECTION OF STORAGE BATTERIES AND SYSTEMS OF WHICH STORAGE BATTERIES FORM A PART

The wide application of storage batteries in connection with electrical installations of various types renders desirable a knowledge of the forms of protective apparatus best suited to the requirements of this class of service. The manner in which the storage battery is handled plays a very important part, both in determining the length of its life and its efficiency. Where batteries are charged at too high a rate, the plates are subject to sulphating and other forms of injury, from which the battery is slow to recover. Discharge of the battery under abnormal conditions is also likely to cause serious damage. Where storage batteries are constantly under the eye of skilled attendants, guided by suitable indicating instruments, these dangers are perhaps somewhat reduced. They may in all cases be minimized and in most cases entirely eliminated by the installation of suitable protective devices.

Considering first the protection of automobile storage batteries, these are quite frequently charged from a generating plant devoted exclusively to this purpose. Among the contingencies likely to arise, are connecting the battery into circuit incorrectly, so that its electro-motive force shall be cumulative with that of the generators, thus subjecting the batteries to an abnormally high discharge rate; or where the battery is properly connected, it may be subjected to a charging current in excess of its safe limit. Disastrous results from such causes may be entirely prevented by the use of overload circuit breakers.

During the period of charging, should the charging generator lose its field, or for any other reason drop its voltage, the storage battery will tend to reverse into it and operate it as a motor, and this without such indication of abnormal conditions as would attract the eye of the attendant. The battery would thus, to all appearances, be charging, while in point of fact it would be undergoing discharge, resulting not only in undue waste of energy, but wear and tear on the battery and loss of time as well. A somewhat similar condition is likely to arise where the battery is charged from a generator engaged in supplying current to an external circuit. Under these conditions, the causes of reversal of the battery into the generator would be the same as those already cited, and in addition thereto, should the generator for any reason be cut out of service, the battery would take up the load on the external circuit, and thus again the at-

tendant might readily be misled as to the real condition of affairs. Particularly would this be the case if the generator were remote from that point in the circuit to which the storage battery was connected. A reverse circuit breaker in the circuit of the storage battery would serve automatically to disconnect the battery coincident with the first flow of current from it into the external circuit.

Sometimes, in automobile charging stations, a number of batteries may be left in connection with the same charging mains at a time when the generators are disconnected. Where this occurs, the stronger or more highly charged batteries will discharge themselves into those more nearly exhausted, and should any one of the batteries be short-circuited, this would result in injury to all of the others. This contingency also may be guarded against by the installation of a reverse circuit breaker in each battery-charging circuit as shown in Fig. 4, which represents a panel such as may be employed in charging a battery from a constant potential circuit, the current being regulated by the line rheostat shown in the lower section of the panel.

Very frequently batteries, particularly those of automobiles, are charged from a motor-generator especially installed for that purpose. In such instances, most frequently the circuit from which the motor side of the charging set is driven is in connection also with other apparatus. If for any reason there should be an interruption of the motor circuit, as might be occasioned, for instance, by the opening of the circuit at the power station, the storage battery, if not promptly cut out, would run the motor-generator in the reverse sense, the motor end acting as a generator and supplying current to the other apparatus on the feeder. The installation of a reverse circuit breaker in the charging circuit of the storage battery provides the only effective means of protection against this contingency.

Conditions identical with these are frequently met with in telephone work. The suitability of the reverse circuit breaker to this class of service is perhaps best instanced by the large and constantly growing use of this piece of apparatus by the leading telephone companies.

A convenient and effective method of installing the reverse circuit breaker for the protection of systems referred to is suggested in Fig. 5. "M" is the motor and "G" the generator, the voltage of the latter being controlled by the field rheostat "R." At "D" (frequently combined in a single case) are the voltmeter and ammeter, the latter in the battery circuit, while the former, by means of a two-way switch, may be used to measure either battery or generator voltage.

"C" is a three-pole combined over-

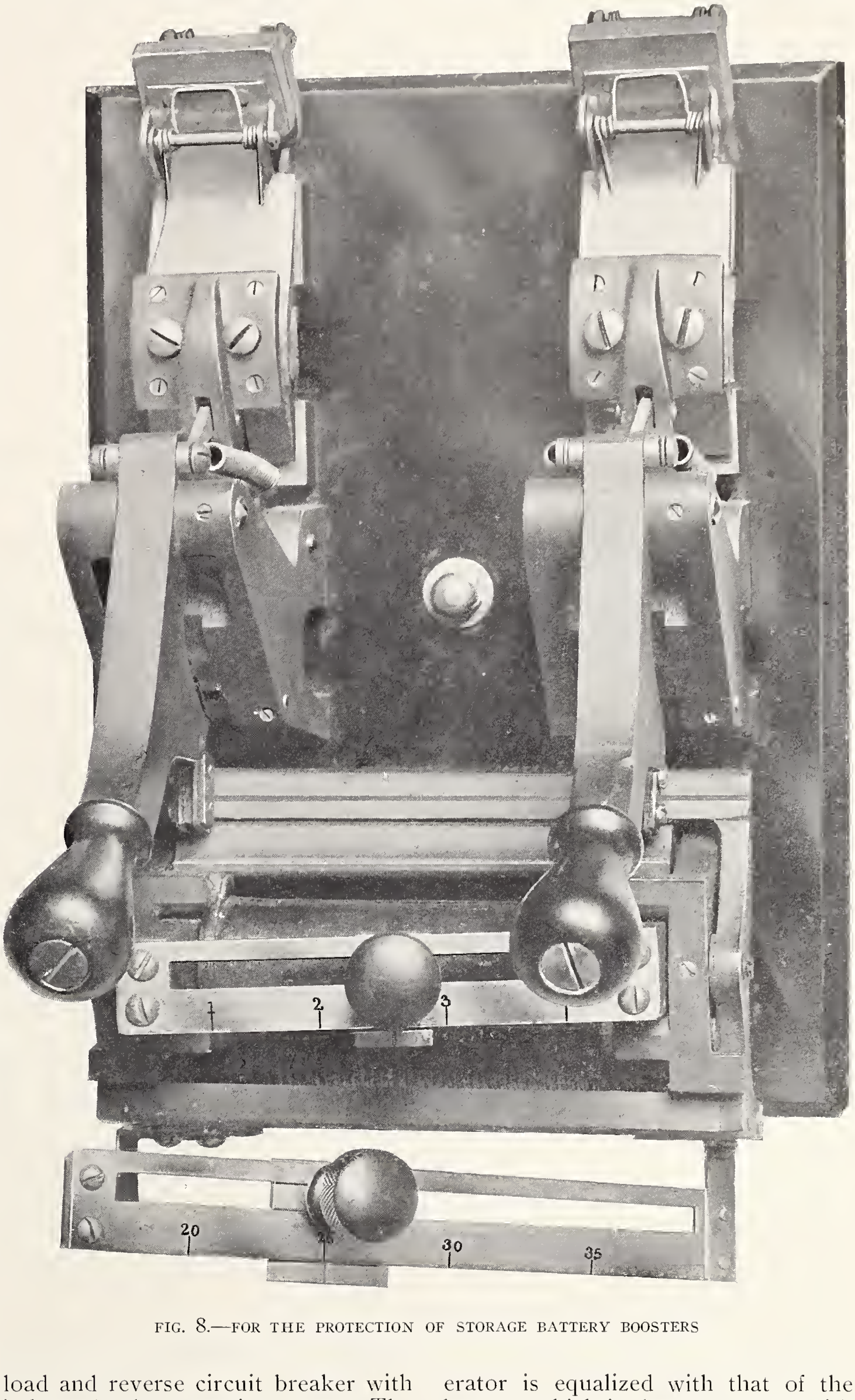


FIG. 8.—FOR THE PROTECTION OF STORAGE BATTERY BOOSTERS

load and reverse circuit breaker with independently operating arms. The pole "2" of the circuit breaker, which includes the overload and reverse current operating coils, is located in one of the mains leading to the storage battery, whose connection with the generator is completed through pole "3" of the circuit breaker, pole "1" of which is included in the motor circuit.

In starting up, the motor circuit is first closed through pole "1" of the circuit breaker; by means of the field rheostat "R" the voltage of the generator is equalized with that of the battery, which is then connected with the generator by closing the two remaining poles of the circuit breaker, after which the voltage of the generator is increased until the proper charging current flows.

While this plan is simple in its arrangement, it is very effective in oper-

ation, and provides for the immediate opening of both motor and battery circuit in the event either of the battery being too rapidly charged, or of its reversing into the generator. It will be seen that the construction of the circuit breaker embodied in this equipment is such that the battery cannot be effectively brought into circuit, either upon reverse current or upon overload conditions. Two independent poles being included in the circuit of the battery, the instant opening of the circuit is insured should an attempt be made to connect the battery under conditions resulting either in an overload or a reverse flow of current. Fig. 6 shows a similar panel employing a double-pole circuit breaker of which one pole only is connected in the battery circuit and one in the motor circuit.

Very frequently storage batteries are installed in multiple with motor-driven generating units, acting under normal conditions as an auxiliary thereto, relieving the generator of the peaks of the load and carrying the load entirely during interruptions of the main source of power. Such installations as these are constantly increasing in use in connection with electrically operated signals, where interruption of the current supply must at all hazards be avoided. In this case it will be seen that the current in the battery circuit may, under normal conditions, flow either in the charge or discharge direction. A reverse current circuit breaker installed between the battery and the external circuit on the one hand, and the generating side of the motor-generator on the other hand, will serve, however, to keep the current in this part of the circuit flowing in one direction only, a reversal of the current from the battery into the generator at once throwing the generator out of circuit, leaving the storage battery to carry the load.

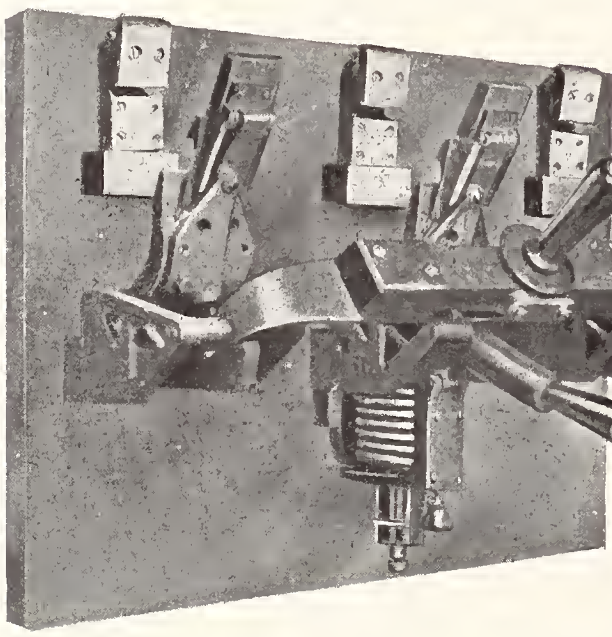


FIG. 9.—INTER-CONNECTED CIRCUIT-BREAKERS FOR BOOSTER SETS

A plan embodying these principles is shown in Fig. 7. Its distinctive feature is that it provides two sets of batteries as a safeguard against shutdown. The arrangement is such that both batteries may be charged or discharged at the same time, and either or both may, if required, carry a whole or a part of the load with or without the assistance of the generator.

These batteries are indicated at "A" and "B." The double-pole, double-throw switch "S" serves to connect either one with the charging generator through the overload and reverse circuit breaker "C." The power is supplied by a two-phase alternating-current circuit controlled by switch "D." The feeders, two in number, are connected with the hinges of two double-pole, double-throw switches, the upper and lower terminals of which connect respectively to batteries "A" and "B." The voltages of generator and batteries are indicated by voltmeters "G" and "H," the latter of which is controlled by a two-point switch, so that it may be connected with either battery. A field rheostat affords means of varying the voltage of the generator which is shunt-wound. By using a circuit breaker with sufficient number of poles, the motor side also of the charging set may be disconnected simultaneously with the opening of the generator side. This, however, is in many cases a refinement of economy rather than necessary means of protection.

In lighting and power work a storage battery is sometimes installed in multiple with the generator, charging from it at low loads, assisting it by carrying a portion of the heavier loads. This class of service demands treatment somewhat different from the foregoing, and its requirements may usually best be met by installing a reverse circuit breaker, the series actuating coil connection in the main circuit of the generator, between it and the storage battery, the switch number being in the battery circuit. The battery will thus be free to charge from the generator or discharge into the external circuit, but any tendency to reverse into the generator itself will cause the immediate severance of the storage battery circuit, leaving the load upon the generator.

For all of the classes of storage battery work referred to in the foregoing paragraph, it is believed that the reverse circuit breaker (with or without overload actuation, as dictated by the conditions to be met) affords the best possible protection.

For the charging of storage batteries at constant voltage, an underload circuit breaker often affords entirely satisfactory protection. It is to be remembered, however, that this device will not remain closed unless there is flowing in the circuit a sufficient current to restrain the underload armature. Where the voltage of the conduit is liable to fluctuations, this would result in frequent and unnecessary opening of the underload circuit breaker, a condition entirely absent with the use of the reverse circuit breaker, which will not only remain closed when no current is flowing in the line, but, as before explained, requires an actual reversal in the direction of the flow of current to cause its operation.

THE PROTECTION OF STORAGE BATTERY BOOSTERS.

The discussion of the protection of storage batteries leads naturally to the consideration of means for protecting the booster sets commonly used in connection with battery installations. In the majority of cases, where boosters are employed in such systems they are used reversibly, that is, they are employed to regulate both the charge and the discharge of the storage battery. Obviously, therefore, reverse current circuit breakers, as usually understood, are not suitable for the protection of this portion of the circuit. The combined overload and reverse circuit breaker may, however, be admirably adapted to these conditions. When intended for such service, the reverse current adjustment is made to correspond with the maximum safe charging rate of the battery, the overload adjustment conforming with the maximum safe discharging rate. Adequate protection is thus afforded to the battery with either direction of the current flow.

Boosters of the compound or series type, if left connected with the system when the circuit of the driving motor is interrupted, will act as series motors rotating in the reverse direction, and, if not promptly disconnected, will attain a destructive speed. Similar conditions occur should the booster circuit be closed before the motor has been started, or should the motor for any reason lose its field. Proper protection under these conditions is secured only by having an overload and no-voltage circuit breaker in the motor circuit in such a manner that the motor circuit breaker must be closed

before the booster circuit breaker can be made to latch, while the opening of the first-named instrument instantly causes the opening of the second.

The inter-connection of the circuit breakers may be either electrical or mechanical. Where the electrical method is employed, the booster breaker is provided with an auxiliary tripping coil brought into circuit by means of a contact device operated by the opening of the motor circuit breaker. In the mechanical arrangement, a lever suitably connecting motor and booster breakers is actuated upon the opening of the former, to release the latch of the latter. This method of inter-connection is illustrated in Fig. 8.

THE PROTECTION OF BOOSTERS SUPPLYING FEEDERS.

Boosters employed to compensate voltages losses in feeders, incident upon transmission over considerable distances are either series or compound wound; if, therefore, when for any reason the driving motor is not receiving current, the booster should be left in connection with the system, it will run reversely as a motor, and in view of its series fields winding will attain destructive speed. This condition may be adequately dealt with by the employment of inter-connected circuit breakers as described in the foregoing section, the motor circuit breaker being of the overload and no-voltage type, while the circuit breaker in the booster circuit will, as a rule, need no other actuation than that transmitted from the motor breaker by the inter-connecting device.

Fig. 9 shows a type of circuit breaker which has been very successfully employed in connection with the booster sets having a generator on each side of the line. The outer switches serve to connect the two boosters to the positive and negative sides of the line respectively; the center circuit breaker operating upon either overload or no voltage serves also to cause the opening of the booster switches.

Cable Cutting

By Capt. GOODRICH, U. S. Navy

From the Proceedings of the U. S. Naval Institute

THE cutting of submarine cables during war has for its object the interruption of intelligence and is merely one of the operations incident to breaking the enemy's line of communications,—the latter a term of broad scope, although chiefly applied to the means by which an army or a fleet is kept in touch with and supplied from its base.

It is evident that whatever interrupts the forwarding of stores and ammunition (the material needs of an active force), or the interchange of information and the delivery of orders (its moral needs), must, of necessity, deal a serious blow either through stopping the stream of provisions and munitions of war, without which an army becomes innocuous, or by intercepting the messages of information and instructions upon which depend the proper handling of the troops or the ships.

According to the circumstances of the case, the latter may indeed be as pregnant with military results as the former. It was with masterly comprehension that Napoleon remarked, "Le secret de la guerre est dans le secret des communications," an aphorism illustrated by his own successful campaigns of Marengo, Ulm and Jena, and by his disastrous advance into Russia. In more recent days, it was the control of the lines of communication which enabled Admiral Sampson to work out his scheme of campaign with a completeness now historic.

Modern treatises on the subject, recognizing the importance of that branch of the communications which relate to the transmission of intelligence, discuss at length the duties and responsibilities of a director of telegraphs on the staff of the general commanding and the details of the field postal service. In the war of 1870 there was a director of military telegraphs on the staff of the commander-in-chief, whose responsibilities are briefly described by Von Schellendorf in his "Duties of the General Staff" as regulating "the whole telegraph service in the theatre of war."* In the war of the United States with Spain the telegraph service was undertaken by the army signal corps with but indifferent success. Its attempts to interrupt the enemy's cable communications failed utterly. Says Col. Furse, C. B.:—

"Notwithstanding these disturbances, no commander in our days would think of taking the field without the aid of the electric telegraph. Who can fail to appreciate the immense advantage it is to him to possess an exact knowledge of all that is passing in the scattered parts of his army? Consider the benefit of his being able to place himself in direct communication and interchange views with his subordinates, with what confidence he can give directions, impart the result of the operations of lateral columns, indicate the assistance to be expected from them, and the time likely to elapse before this aid may reach its destination. Look how the operations of two or more armies, separated by some impassable natural barrier, have ceased to be such a risky thing as they have hitherto been; for, thanks to the electric telegraph, their commanders can now combine their movements and can be in constant intercourse."

This picture of the tragic conditions of warfare on shore is but a tiny miniature when compared with the vast canvas required to depict the operations of fleets and squadrons. The distances in the one case are measured by single miles, in the other by hundreds of leagues. It was the submarine cable which told Cervera of the attack on San Juan, Porto Rico, and thus turned him away from the destination to which he had been ordered and which Sampson had rightly guessed. Had the lines leading to Porto Rico been promptly cut at the outbreak of hostilities, Cervera would have met, off San Juan, the fate which befell him on the 3d of July, and the war would have been over before it had fairly begun.

It follows from these preliminary considerations that accurate information as to the location of all submarine telegraph lines should be at the disposal of our commander-in-chief that he may know where it will be most advisable to send a vessel to cut such lines as lead to the enemy's territory. This is no new suggestion. Although our experience during the war with Spain demonstrated its value, the suggestion itself had previously been made in one of the most important papers ever read before the Royal United Service Institution of Great Britain. Pointing out in 1881 the pressing necessity of establishing an Intelligence Office at the Admiralty, Sir John Colomb mentioned, among other duties, "It is also of importance that all particulars concerning the exact position, nature of bottom, and depth of water in which submarine cables are laid should be collected and furnished to naval commanders, so that they may know

* Said Major-General Webber, R. E., twenty years ago, "When the army learns to apply the telegraph as extensively to a line of communications as it is used by railway companies, commensurate results will be produced in war."

where to cut or tap them, or prevent others from doing so."

I am unable, through ignorance, to state that our own excellent Office of Naval Intelligence is in a position to supply this information with that exactness which Sir John had in contemplation when he wrote the words just quoted, and I am disposed to believe that the difficulty of obtaining this knowledge is so great as to be for us practically insuperable, since substantially all submarine cables, the world over, are owned by foreign corporations and controlled by foreign governments. It is not likely that these corporations would reveal the location of their various lines so frankly and so fully as to facilitate their destruction in time of war. While not pretending to assert that the precise information which would have been so valuable to us in 1898 was not in the possession of our Office of Naval Intelligence, yet I may say that it did not reach either of the parties that undertook to cut the lines leading to Cuba.

The lack of definite knowledge of the locations of cables does not, however, operate as a hopeless bar to their raiding. The terminal points are known to every one who cares to consult the diagrams of cable connections which are freely open to the public, and which are printed in our own Hydrographic Office.

To trace the intermediate route is not very difficult, if you keep in mind one factor of determining importance. Of course you will, in this way, only get an approximate, or probable, location, but you will not be very far from the truth. This factor is cost. Each deep-water cable is worth about one hundred pounds sterling a sea mile, and each knot saved means less capitalization and greater economy in laying and maintaining. You may be pretty sure, therefore, that the wire you seek has been run in a straight line, or as nearly in a straight line as topography and hydrography permit. Along a convex coast it is to be sought not far from the beach, and preferably in not less than 30 fathoms.* Along a shore-line consisting of capes and bights it shaves the points. In no case is wire unnecessarily paid out, and this hint will give you the clue you require. You may with confidence lay down on your chart the probable course of the cable from start to finish and then take up the next question in order—where is the best place to attempt the grappling?

Military considerations may confine your movements to a narrow zone. In this case you have no choice and you must do the best you can under the circumstances. If, on the contrary, you are free to go where you please, you will study the chart with care and select a point where the water is shallow and the bottom free from rocks. In deep water, much time is consumed in making a "drive,"

FIG. I.

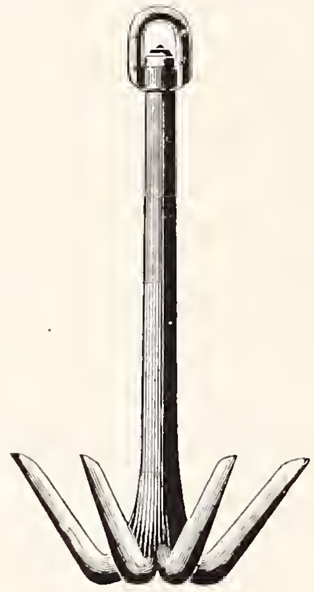


FIG. 2

as the trip across the line of the cable is called, and the difficulties attending the hooking on and heaving up are greatly increased. On rocky bottom the cable lurks among boulders; a grapnel is apt to pass over it without hooking, or to be caught on a stone and its prongs straightened out like an umbrella turned inside out by a sudden gust of wind. Should the bottom be shelving, the drive is made up hill, or from deep water into shoaler water. It is hardly necessary to add that the direction is square across the lie of the cable.

You have now determined upon the place where your search is to begin and upon the general line to follow. Let us consider briefly the mechanical means to the end we have in view. The appliances needed by a ship assigned to the duty of cutting cables are few in number and simple in nature. They consist essentially in a suitable instrument for grappling the cable, a stout and flexible line attached to the foregoing and a steam windlass or capstan for heaving in. It will be apparent on reflection that the first is more likely to be a special tool than the others and one which, in its higher development, is not likely to be found in the naval service.

A sounding machine capable of reaching bottom at a thousand fathoms or more may be very helpful, but it is by no means indispensable. If you cannot get a cast with the lines you have, you must do as I did off Santiago, use the grappling hawser itself for a lead line. Other things being equal, the best results in all mechanical operations are achieved with apparatus designed solely for the particular task in hand, and containing in its plan and workmanship the highest skill, deepest thought, and widest experience of the expert. The job can be, and often is, done with inferior facilities, but time, labor, and patience must be expended to replace the unerring precision and rapid output of the special machine.

A few words devoted to study of the most successful forms of grapnels will not be amiss, for the latter will convey hints as to improvising, which may prove of great value. If we pause to reflect upon the way in which a cable rests upon the bed of the ocean, we shall realize that the conditions may so vary from place to place as to present a wide diversity of problems to solve, the variable being for the same cable the changing character of the bottom.

The cable may hang in a long bight from crest to crest of a valley; it may lie on a generally level floor, yet nestling among boulders and rocks so closely as to be almost secure against grappling; it may rest easily on a hard bottom; it may have sunk deep into mud and ooze. Plainly, what will pick it up in one case will fail to dig it out in another; what will dig it out here will not get within its stony guard there. And so we find that the nature of the bottom has forced the clever men charged with the maintenance and repair of submarine cables to devise grapnels appropriate to the particular needs in each instance. Fortunately we may, in a rough telegraphic fashion, divide ocean bottoms into three classes, soft, hard and rocky. If we know, in a general way, what tools have been invented for use on these three classes of floor, we shall be helped in our improvising when it falls to our lot to drag for a submarine cable.

The exemplar and forebear of them all is the grapnel known to sailors from the earliest ages. When it was found that the ordinary grapnel was too light, the weight was increased up to 500 pounds as a maximum; 200 pounds may be accepted as a good working figure. It was soon seen that the short shank and the long prongs made a grapnel jerk and jump on hard bottom, so for this latter use the prong was shortened to a scant hook and the shank lengthened. Neither of these forms being satisfactory among rocks, it occurred to some nameless expert to use a heavy bar of iron or steel about 4 feet long provided with numerous short hooks distributed along its four sides, trusting

* In shoal water the surface agitation is transmitted to the bottom, where it chafes and injures the lightly-armored deep-sea cable.

to its shortness and its weight to search out the interstices between boulders and thus seize the cable in its hidden lair. Such was the origin of the fitly named centipede, the third of the types of grapnels employed by cable ships.

I have mentioned them so far in their simplest form, but it is not to be supposed that so highly organized and costly a service should not have evolved modifications to meet certain difficulties which arose from time to time. Thus you may readily imagine a grapnel to have picked up a cable and, before being lifted clear, to have caught its prong in a rock. The simple type would have opened out the prong and have lost the wire. Here ingenuity entered and suggested either a spring which would hold the prong extended except in the event of too great a strain, or a prong held in position by a soft pin. In the first instance, the spring returns the prong to its place when the strain is eased up; in the second, the pin of lead or soft iron is sheered, the prong swings open on its ringe, but in both cases the cable is still held by the shoulders of the lugs between which the prong revolves, or by projection on the shank itself. With the simple grapnel this same end is secured, sometimes, by a spring which holds the cable even if the toe straightens out. Another improvement is sought in a means by which a cable, after being grappled, may be cut, one end dropped and the other, firmly held, brought to the surface.

Should any of my hearers care to dig deeper into this subject, they may consult Prof. Jameson's paper on "Cable Grappling and Lifting," in the "Journal of the Society of Telegraph Engineers," Vol. II.; the "Electrical Review," for January 11, 1895; Mr. Frank Lambert's paper read in 1876 before the Society of Telegraph Engineers on "Grapnels for Raising Submarine Cables in Deep Water"; Mr. Chas. Bright on "Submarine Cable Grapnels," "Engineering," November 4, 1898, etc. The illustrations to which I shall now refer may be found in the latter article. Fig. 1 is the short-toed grapnel for use on hard bottom, such as sand and gravel; Fig 2, the long-shanked, long-toed grapnel, for use on soft bottom, such as mud and ooze; Fig. 3, the conventional form of centipede.

In a centipede ordered for the "St. Louis," but never used on account of the speedy collapse of the Spanish resistance, a 5-inch iron pipe was substituted for the bar. Holes were drilled through it from side to side, square bars of $\frac{3}{4}$-inch steel about 15 inches long were forced through these holes, the ends bent in the same directions, and the metal was upset to hold the claws firmly in place.

I have thought it well to exhibit a grapnel of special make to illustrate one successful manner in which the problem had been solved. Fig. 5 shows two Stallibrass grapnels coupled together for centipede work, and Fig. 4, the details of the grapnel itself. The toes are pivoted about the bolt A, their heels resting against the soft iron pin B. When the strain is too great, the latter shears and the toe drops into the dotted position, freeing the grapnel from the rock or other obstruction, but the cable remains caught and firmly held in the round seat shown in the figure. A capsized toe tends to throw the grapnel over and a sound toe down, something which invariably does not happen with the ordinary grapnel. It is stated on authority, that so long as one toe is in its normal position, the Stallibrass grapnel may be relied upon.

I will not waste your time over the so-called "Cutting and Holding Grapnel." If you should need one, it will be better to buy the tool, of which, it may be remarked, numerous varieties are in use.

It is always well to place a length, say 15 fathoms, of $\frac{1}{2}$-inch chain ahead of the grapnel. The object is twofold, first, to weight the ring of the grapnel and thus hold it down to its

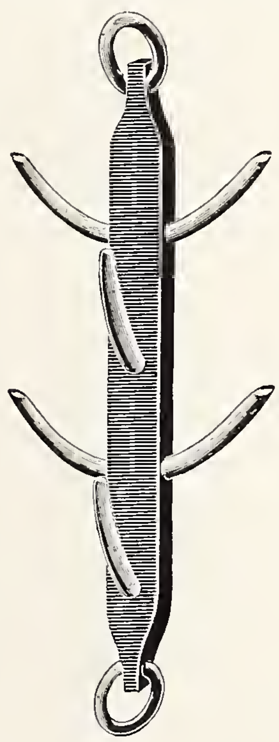


FIG. 3

work; second, to avoid chafing the line. It may also be seen that such a chain will fall into the spaces between rocks and so guide the grapnel to its object. As there can never be any disadvantage in using the chain, and as it is frequently of great utility, I suggest its employment as an invariable rule.

The line or hawser may be anything stout enough for its purpose. Practically you will be doubtless thrown back on what is available. The depth of water will suggest an appropriate size. But a heavy "shore end" may demand in grappling as strong a hawser line as a lighter cable laid in deep water. I have personally used manila hawsers from 5 to 8 inches in circumference, but, for the reason that no others were to be had.

The operation of grappling is directed by one officer who keeps his hand on the hawser and from the vibrations which it transmits from the grapnel hundreds of fathoms below, he forms an idea of what is going on at the bottom, which is correct in direct proportion to his experience. Little shocks, like a succession of tremors, tell him that the grapnel is slipping along a reasonably smooth floor; a heavy strain followed by a sudden release, that it has fallen among rocks; a gradual increase of tension always accompanies, although it is not the invariable proof of, the hooking of the cable.

From these facts it will become evident that the lighter and more flexible the grappling line, the more truly and delicately will it transmit the vibrations originating at the bottom, and the more accurately may these vibrations be interpreted. Use therefore the lightest line of sufficient strength. Here again, special wants have brought about special means, and the grappling line is now as much an article of manufacture as the submarine cable itself. Strength is secured by the adoption of steel wire (galvanized to prevent corrosion), and flexibility is gotten by using many fine wires, laid up into seven strands, each strand wrapped in tarred hemp. Get this if you can, but remember that it is a convenience only, not a necessity.

The cable ship inserts a dynamometer before the wind-in machine to obviate heavy surges. The same end may be reached in a cruder and less effective manner by a steam winch with a variable throttle in the hands of a skilful person who acts in obedience to signals from the officer in charge.

A cable may be hove up by a windlass or capstan out of sight of the grappling officer, but the chances of breaking the wires are thereby enormously increased. If your forecastle winch is too small in the heads for rapid work, it may be necessary to enlarge the latter by wooden chocks or whelps—but avoid the mistake of making them so large that the winch power becomes inadequate.

While the smaller ship is handier.

there is no real limit to the size of the vessel which may be used for this purpose. My own experience was had in the "Suwanee," in the "Wompatuck" of 460 tons displacement, and the "St. Louis," displacing 17,500 tons, the largest vessel, by the way, which ever flew a pennant.

On arriving at the spot chosen for cutting a cable, the first thing to do is

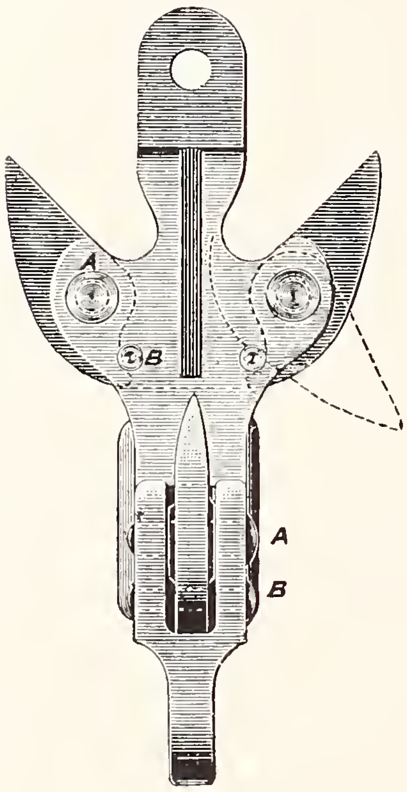


FIG. 4

to stop the ship dead in the water and ascertain the depth, unless this is given by the chart. It is possible that you may not have enough sounding wire to reach the bottom. This, I have said, was my case off Santiago. There is then nothing left but to lower the grapnel over the bows and bend on hawser after hawser until the grapnel strikes the bottom. You will have taken such a position as will enable you to drag up hill and you will begin the drive far enough on one side of the known or assumed line to be certain that the wire lies ahead of you.

The dragging is always done over the bows, as that is the one end of the ship which may be controlled. The grapnel is on the weather side to keep the line clear of the screw. The more slowly the ship moves the more likely is the grapnel to seize the cable. Her advance should be so gradual as to be hardly perceptible. The best way of measuring her speed is by means of a "Dutchman's log," small billets of wood thrown upon the surface of the water from time to time. The grapnel creeps over the bottom, its prongs burrowing slightly under the surface of the soil until they catch underneath the cable. The gradually increasing tension on the grappling rope reveals to the expert, whose hand is always on the outboard part, that the cable is caught.

It is well to keep going ahead for a few minutes after getting an unmistakable bite in order to lift the cable off the bottom, and thus ensure its being hooked. Then the ship is stopped and the line, taken to a steam winch or capstan, is hove in. As soon as the bight is well out of water, a hawser is bent to it and the grapnel relieved of its duty. When the cable is inboard, a stout plank to protect the deck, a couple of sharp blows with an axe and the thing is done. Letting go of one end and steaming a couple of miles away with the other will make a gap of sufficient magnitude to embarrass the repair steamer, should she come along before peace is declared.

I think there can be no reasonable objection to our including a properly equipped cable ship among the indispensable auxiliaries to a fleet or to our insisting that she should be of the navy, under naval control absolutely —and not like the "Adria," for example, a chartered foreign steamer under the control of a staff officer of the War Department in Washington. Captain Squier, U. S. A., is quite right when he claims that "it may be said at present that no modern fleet is complete without a cable ship especially designed for cable operations in time of war."

I cannot leave the subject of cable cutting without making the suggestion that the other side of the medal ought to receive attention from the naval authorities in general and the General Staff in particular, in order that some provision or arrangement may be made in time of peace for the laying of such cables as are thought or found desirable in putting the plan of campaign into actual operation.

Only half our work is done when we interrupt the enemy's communications—we must keep our own intact, and we must supply such missing links or such ramifications of the existing network of commercial cables as will serve to maintain our commander-in-chief in touch with the outside world, should he so desire. If he prefers, like Dewey, at Manila, to drop a veil behind him, cut himself from his base and work along his own path unhampered by instructions from Washington, that is assuredly the prerogative of his high office. On the other hand, if he thinks it wise to follow the example of modern generals with their field telegraph companies and organization, then he should have at his command vessels for laying submarine cables either of the special design in universal employment by the great corporations, or improvised craft fitted in a rough manner with suitable instruments and provided with sufficient wire stout enough to stand the unavoidable strains, and yet slight enough to occupy small space in the hold. Obviously, a wire for temporary use may, properly, vary in many respects from the established pattern evolved for permanent use on well-known routes. Such a cable would naturally be so run out as to escape ready detection by the enemy and its starting point would call for adequate defense. It seems to me that the utmost simplicity is "sine qua non" in all parts of this temporary installation.

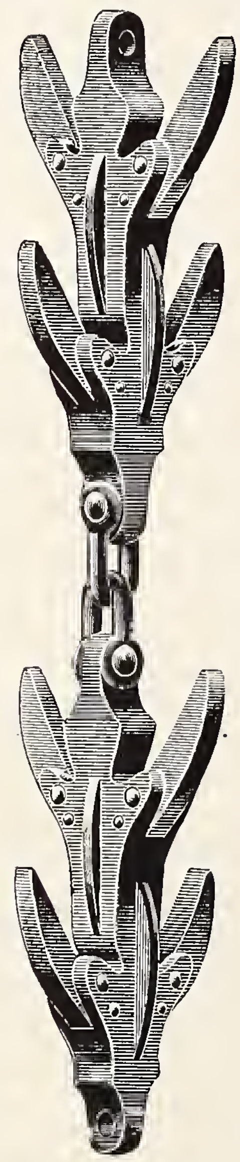


FIG. 5

Thus, from the desirability of severing our enemy's lines and of maintaining our own communications, the double need arises for the cable ship alluded to above. I think that she will come when the clouds of war next gather on our horizon, and that when she comes she will come to stay.

Recent experiments by Professor John Trowbridge, of Harvard University, are understood to have demonstrated that the cause of thunder is to be found in the dissociation of water vapor.

The Education of the American Electrical Engineer

By Professor W. E. AYRTON

What Professor Ayrton has to say concerning the education of the American electrical engineer is based upon his observations during the recent tour through the United States of the Educational Commission sent out from Great Britain by Mr. Alfred Mosely. Professor Ayrton was one of the members of that commission, and thus enjoyed exceptional opportunities for the "gathering of impressions."—The Editor.

ALTHOUGH I take a keen interest in primary and secondary education, as well as in business and technical education, and although, therefore, I visited various American elementary schools, trade schools, schools of commerce, and technical schools, in addition to universities, technical colleges, and factories, the shortness of the time during which I could stay last autumn in the United States induced me to devote myself almost entirely to the study of one branch of education, viz., that of the young electrical engineer. The information gained during the three weeks, combined with what I have learned during former visits, enables me to state conclusively that, as far as the training of the young electrical engineer is concerned, the United States are, on the whole, distinctly ahead of Great Britain.

It was not because I found some of the electro-technical laboratories in the States larger and better equipped than in my own country, nor because some of them contained full-sized machinery instead of mere models, nor because I saw large numbers of students working in them, that this opinion of the superiority of the teaching of the young electrical engineer was forced on me. But it was because I saw that there actually existed that close bond of union between the industry and the teaching which only the more sanguine of us have hoped they might perhaps live to see introduced into our own country.

I talked with manufacturers and managers of works, with engineers having a large consulting practice, with engineers having a small one, with municipal engineers, with presidents of engineering societies, with presidents of universities, with professors of engineering, with the staffs in laboratories, with students in college, and with the editors of technical papers, regarding the relation between a college and a factory. All the people of the classes enumerated above whom I met were unanimous on two points—there was not one dissentient voice. Everywhere I was told:—An engineering apprentice in a factory should be a college-trained man; an engineering professor in a college should be actively engaged in the practice of his profession.

At the Westinghouse Electric and Manufacturing Company's works, Mr. Downton, the foreman of apprentices, said:—"The engineering apprentices, of whom we have about 150, must be first-class graduates of leading technical schools. We start them on trial at 16 cents an hour, and if really bright they may be earning $150 a month with us at the end of eight months. We are always on the lookout for bright men; we co-operate with the professors of colleges to get them."

Two of the chiefs of the staff visit all the principal universities, colleges, and technical schools throughout the United States every year for the purpose of seeing the students and choosing those who are most suitable to work with the Westinghouse Company.

"The Westinghouse works are the product of the colleges of this country," said the chief electrician. "We have come to rely on college men; we are now practically all college-bred men ourselves. And yet when I came to Pittsburg and knocked at the side door of a factory, the fact that I was a college man counted against me in the mind of the superintendent. Now the same firm sends each year to the technical schools asking for their best men, and sometimes during one yearly visit we take the whole class from a college."

At the General Electric Company's huge works at Schenectady, on the same vast scale as the Westinghouse works at Pittsburg, I found the same scheme carried out. The electrical superintendent, Mr. C. P. Steinmetz, and the general manager, Mr. E. B. Raymond, both spoke of their feeling "the need of technically educated men in all departments"; how they only take for their "365 test students graduates of colleges of high standing"; how "they together visit each year all important colleges as far West as Illinois and Ohio to see the professors, to see the men who contemplate going into practice," so that they may choose some 150 bright college youths every year; how they had met on these annual visits representatives of other large electric works on the same quest; how they all aimed at fostering "a mutual alliance between the factory and the college"; how that, because a student happened to be good at drawing, they did not keep him in their "draughting rooms, but let all students go through department after department so as to learn."

"Thirty per cent. of the students of the General Electric Company are British, and within five months the English students drop into step and hustle." I discussed with a group of former City and Guilds Central Technical College men now at Schenectady how the students at their old college could be made to acquire that alertness and go-aheadness that we saw all around us there, and they advised, "Send as many of them as you can to America."

I suggested to Mr. Wm. Barclay Parsons, the chief engineer of the new underground electric railway of New York, for whose engineering staff men are selected by examination, that perhaps the reason why so large a percentage of college-bred men were chosen, was because the examination questions were such as a college-trained man could better answer than one who had entered on practical life when quite young. But he showed me copies of the questions, and convinced me that they were such as an applicant for an assistant engineership ought to be able to answer, whatever had been his previous training.

Now, one of the reasons why, in spite of the many places at which electrical engineering is taught in America, the demand for college graduates

is still greater than the supply, is because the education which they have received is exactly what the manufacturers desire. It is not given by teachers, the terms of whose appointment divorce them from industry, by men who perhaps even learn to look down upon the manufacturer, the engineer, the manager, and the salesman, although these people are actually occupied in practicing that very application of science to industry which the teacher preaches, but by those who are doing the engineering work of the country.

There is no question about an engineering professor in America being occasionally permitted to do a small amount of outside work: he is practically required by the college authorities to be so actively engaged in practice that he becomes recognized in the world of affairs as the working authority on the subject.

I had a long talk with President Schurman, of Cornell University, where there are about 1200 students of engineering alone. He considered that there was no question about the importance of the engineering professors engaging in practice, but that when a professor was away from the university for six months doing private outside work, he had been led to ask the Dean of the Science Faculty, "Are we losing this man's time?" The reply, however, had always been, "The university gains."

Dr. Alex. C. Humphreys, president of Stevens Institute of Technology, a college for the training of mechanical engineers only, said:—

"I consider distinctly that an engineering professor should be interested in business. If a man is not capable of doing outside work, he is not capable of teaching. The Stevens Institute Department of Tests may carry on any outside work in the Institute's laboratories, and may retain all but 10 per cent. of the fees they receive."

On each of the many occasions that the importance of outside work was urged on me, I pointed out the possible risk of a man becoming so immersed in professional work and deriving so large an income from his practice that he might come to disregard the salary derived from the university and neglect his students. But I was always answered that the risk I referred to was far less serious than the risk of the professor's teaching deteriorating from his losing active touch with the industry.

"Reality" is the watchword of engineering education in America, for not merely are the professors on the faculty of an American college engaged in real outside work, but several lectures are given yearly by engineers who are otherwise wholly engaged in practical work, and not connected with the college.

In America much less importance is attached to examinations than in Great Britain. Whether a student is worthy of a degree is left to the decision of his professors, without the intervention of outside examiners. They are greatly influenced, they told me, by their estimation of the value that the student will be to the world. On the other hand, America's judgment of a professor is based on his power of attracting students, on the demand shown by the industry for the men he turns out, and generally on the name he makes for his college.

America being a go-ahead country, and the land of youth, one is somewhat astonished at being told by various thoughtful people—from the President of the United States downwards—that there is a growing impression that a student should not leave the professional school until he is 24 or 25 years old. For they urge that, after leaving the high school at 17 or 18, he ought, before proceeding to the professional school, go to college to learn "classics and culture," since an engineering student should receive considerable literary training to fit him to become the all-round man who can command commercial success. Some American engineers, however, think that 24 or 25 is too late for a student to enter the factory, and so they suggest, as an ideal course for an electrical engineer, something like the following:—At the public elementary school, 6 to 14 years old; at the public high school, 14 to 17 years; at the university, 17 to 20 years; at the technical college, 20 to 23 years.

In England even 23 would usually be thought too late to enter works, because it would be feared that the man might not so readily take off his coat and buckle to as at an earlier age. But it must be remembered that the American students, while at the technical college, are taking part in outside work under the practical engineers who are their college teachers.

Organization is a marked feature in American undertakings. At any important university, for example, the engineering teaching is subdivided between several professors, each giving instruction in his own particular branch or sub-branch. In England, on the other hand—even in its capital —over 150 students may be found in the electrical engineering department of a college, men carefully selected by entrance examinations, men giving their whole time all day, every day, to the study of their profession, and yet one single professor of electrical engineering, with a staff of poorly paid assistants, is considered sufficient. Yearly some of the students may go out into different lines of electrical work, and yet that professor, while staying the greater part of his time inside the college walls, is expected in some miraculous fashion to keep himself in practical touch with all these branches so that, no matter what may be the one a student may select, that student shall be well prepared to enter on his profession.

Educational authorities in America agree with our own in deprecating the idea of one building, or set of buildings, being used by students up to graduation, and another building, or set of buildings, for post-graduate students. They consider that one professor, with his staff, should give all the teaching—ante and post graduate —in one branch. Ante-graduate students should not feel that they had merely to acquire knowledge, and that its advancement should be left solely to the post-graduate one. All students (junior or senior), all teachers (young or old), should learn to inquire, and in order to do so they should have the chance of seeing one another at work.

In fact, if the best teaching and the greatest development in each branch is to be secured, the Americans think that the division lines should be drawn vertically between branches of the subject, and not horizontally between students of different ages.

As in the American college, so in the factory, the effects of organization are very noticeable. At a large electrical works one man is expected to be the authority on direct-current machinery only, another on single-phase alternating-current machinery only, another on polyphase alternating-current machinery only, etc.; hence each line receives constant development.

A comparison between students in the two countries shows that the American student is usually not as scholarly, nor as well read, as the English student of the same age, but "he has his knowledge in a better form to apply." The British system turns out a man full of knowledge and principles, while the American product is a business man with a scientific training. The characteristics of each nation have their advantages. To America we look for that rapid, bold, and successful application of science to industry which has brought about the commercial invasion of the world, while to Europe we look for those scientific imaginings and creations which are apparently so unimportant to-day, but which to-morrow revolutionize old industries and give birth to new ones.

My grateful thanks are due to all my American friends for the great help and the many kindnesses which they have always showered on me. And even during this last visit, when, in order to obtain information, I was compelled to give them much trouble, and when, to avoid deriving an exaggerated impression of the superiority of the young American electrical engineer, I was forced to display a doubtful and critical spirit, they invariably showed that sweet and lovable courtesy which I have always found so characteristic of their nation.

Electric Meters in Light and Power Service.

In the early days of electric lighting, when meters were unknown, light was sold on a flat-rate basis. This method proved unsatisfactory from the fact that it could not be controlled to receive pay for all current used. To make an average rate that would bring returns for all current used would under the flat-rate system make charges unreasonable for many customers, and from this demand for equitable charges the electric meter was evolved.

Not every one realizes how much the financial success or failure of the electric-lighting business depends on the meter, and George S. Carson, in a paper read before the Iowa Electrical Association, has endeavored to create a larger appreciation of this fact.

The first efforts in making electric meters were not very successful. The moving parts were heavy, causing undue friction, with the result that the meters proved unreliable. Experience and brains, backed by unlimited capital, have solved the problem, so that to-day we have electric meters that are accurate to even a 50 per cent. overload of their rated capacity. They are as far superior to the first meters made as the fine Waltham movement is superior to the Waterbury. From this we must not judge that all meters are perfect when received. The rough handling by transportation companies often causes inaccuracies, and it is therefore best to test all meters carefully on receipt. In installing meters care and good judgment must be used and directions of the makers carefully followed. Accurate registering cannot be expected if these directions are not complied with.

Notwithstanding the proved accuracy of the electric meters of the present day, Mr. Carson said that there are still many of the lighting companies operating on the flat-rate system. The question of extra investment for meters and trouble anticipated in changing to meter basis is holding back many from adopting their use.

On the first question of extra investment a preliminary test should be made to ascertain whether the installing of meters will pay interest on the investment. Let the companies who are in doubt install meters on the switchboard that will register the total kilowatt output of the station. This can be done at a reasonable cost. Then from the gross receipts of any given month the price received per kilowatt for all current generated can be figured. A test of this kind will convince the most skeptical that on the flat-rate basis of selling light the receipts per kilowatt are not much more than half what they should be.

From this it cannot be assumed that the consumer will pay double on the meter basis over the flat rate, but that he will use light only when needed, and that his economy in using light will reduce the peak load as well as the average load on the station. This will permit taking on additional consumers and will increase gross income one-third without increasing the peak load or the kilowatt output above what it was on the flat-rate basis.

There is another most important reason why meters should be used, and that is to ascertain the transformer and line losses, and being able to locate them, so that the plant may be operated at a high efficiency.

A station would not think of making a donation of 10 or 20 per cent. of the lighting receipts. Then why should it, in an indirect way, be donating these amounts and more to losses in operation which could be corrected by the use of electric meters, and a system of checking up leakages?

In a central station which Mr. Carson recently tested the switchboard meters on 2000-volt two-phase alternating-current for commercial lighting and power purposes registered for one month 18,450 kilowatt-hours. The consumers' meter total registered 13,806, making the loss 4644 kilowatt-hours, or 25 per cent., so that the current sold was 75 per cent. of all current generated. This was in a station operating a 24-hour service, with a stoppage of six hours on Sundays. In 1901 the system of selling light in this station was changed from flat-rate to meter, so that all meters are comparatively new. All meters are tested systematically, the meter testing being done at the company's office.

Meter maintenance is now recognized as a most important question in the successful operation of the electric lighting and power business. The usual custom is to have a regular testing department, so that all meters are taken down and tested at regular intervals, not waiting until they show inaccuracy. In this way the highest results are obtained, not only in meter accuracy but in testing transformer and line losses of the distributing system. These tests will not be an expense that will be felt, as the results obtained will be a certain gain in the net earnings account.

Nuernberg Mechanical Toys

According to Consul Joseph L. Langer, at Solingen, Germany, the Bavarian Trade Museum has adopted a novel idea to interest as well as to instruct the public and purchasers of toys by sending out traveling lecturers, who show the practical workings of the toys by means of models in actual operation. Some of the more interesting toys thus demonstrated include:—A complete railroad train, which can be run backward and forward, slow or fast, and stopped at will; locomotives, operated by steam power, and other steam-driven machinery, sold at prices ranging from $10 to $40; steam turbines and crushers; and gas, hot-air and electric motors—all in actual operation.

Toy boats of all descriptions are exhibited, including a submarine boat, which is shown at work in a basin, the basin also serving to show a diver (placed in a glass cylinder), who ascends and descends. The exhibits also include automobiles, small fountains, and mechanical optical toys, all shown in motion and explained as to the manner of their manufacture.

A recent month's electrical exports from the United States showed a total value of $830,135. The principal buyers were:—British North America, $103,923; United Kingdom, $94,586; Japan, $71,513; Mexico, $49,860; France, $38,148; British Australasia, $12,318; Argentina, $8691; British Africa, $6585; British East Indies, $6582; Germany, $4710; Colombia, $3029; Philippine Islands, $2657; Cuba, $1780.

An unusually large electric sign adorns the new Butterick Building, in New York City. The sign occupies the entire side of the building facing the North River and is easily readable a distance down the harbor, across in New Jersey and a long distance up the Hudson. The letter B is 68 feet high and the other letters measure 54 feet in height.

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Leading Articles

Mid-Sea Wireless Telegraph News

SIGNOR MARCONI recently arrived in New York after a trip from Liverpool on the Cunarder "Campania," and has again been heard from through the medium of the daily press. It is noticeable, however, that the flourish of trumpets that formerly accompanied this gentleman's utterances for publication was lacking, and his statements regarding the possibilities of his system, if correctly reported, were much more subdued in tone than of old.

The object of Marconi's present trip appears to have been to test the efficiency of some novel receiving apparatus of recent invention, with the view of establishing daily mid-sea newspapers on the various trans-Atlantic steamships. These newspapers are to receive, by the Marconi wireless telegraph system, 200 words daily, embodying the chief news of the world—not a great budget of news, it is true, but the editors of the mid-sea journals may be relied upon to expand the news a little. This is assuming that the project will prove successful. On that point there is some doubt, for in the interviews in question Mr. Marconi only states that one of four systems which he tried on the voyage worked better than the others, and that is the system which he thinks he will adopt.

When one recalls the glowing accounts of the Marconi system that were given out over three years ago, it is more than surprising to learn that any question remains at this late day as to which of the systems of that company is the best. That the wireless news source is not yet ready for operation is further shown by another remark of the inventor to the effect that long-distance experiments of sending at sea will be undertaken within a few months, probably aboard a British warship. This remark will doubtless blight the hopes of those pecuniarily interested ones who have been educated to the belief that the Marconi long-distance wireless system had long since passed the experimental stage, and had nearly reached the dividend-paying point.

According to the statement now made, Marconi received signals from Poldhu at a distance of 1700 miles east of that section during the recent voyage. No messages, however, were sent to Poldhu from the ship. The reason of this is obvious. The system of vertical wires and the high power of the transmitting apparatus at Poldhu are lacking on the "Campania." Consequently, messages from the vessel would not be perceived at Poldhu. Hence, while messages or news might be received by the vessel from Poldhu, there would be no means of informing that station whether or not the message had been received on shipboard until the arrival of the ship at port. When, therefore, the news service is established, the dispatches from Poldhu will be cast upon the air, probably at prearranged hours, and all those who may be able to do so, whether equipped with the Marconi apparatus or not, may pick up the news. For whatever may be said to the contrary, it is not likely that the news will be transmitted in cypher; nor has the art of selective signaling reached the point where any sufficiently sensitive receivers may not receive the despatches.

It appears that doubt has been expressed of the ability of the general operator to take long-distance wireless messages; that, in other words, while Marconi may be able to receive long-distance signals, the general operator is not able to do so. This can mean only that the general operator is not as expert as Marconi in the adjustment of the apparatus, which is possible, or that furthest, the ships have not been equipped with apparatus suitable for receiving long-distance signals. We incline to the latter view, for it is difficult to assume that by this time the practical operators of the system have not acquired a skill in adjustment of apparatus equal to that of Marconi, unless it be admitted that the apparatus employed is intricate to a degree that would seem to render its every-day use impracticable.

Marconi had his little pleasantry with the interviewers. He was politely asked if the operation of his latest system for the reception of news on vessels in mid-ocean could be explained in terms intelligible to the lay mind. To this inquiry he sagely replied that the system consisted of "little coils of wire and little technical things" which will no doubt be readily comprehended by an interested public.

Marconi frankly expressed the opinion that the De Forest system was doing very well indeed in the Far East, but excused himself from saying more on the ground that his company

was suing the De Forest company for infringement of patents.

It may be noted that De Forest has claimed that owing to the sensitiveness of his receiving apparatus and the high speed at which his system is operated, it is not possible for systems employing less sensitive and more sluggish apparatus to receive the signals received by his receiving apparatus. The speed appears to be about twenty-five or thirty words per minute. The maximum speed of receiving by any of the best known filings coherers is about twelve or fifteen words per minute. Consequently, while such coherers might be sufficiently sensitive to respond to signals transmitted by the De Forest system, their inertia is usually so great that they would not record the signals transmitted at the higher rate intelligibly, which is perhaps what De Forest meant to imply by his statement.

Electric Power and Portable Heavy Machine Tools

To most minds, portability in the case of a machine tool carries with it the suggestion of relatively small size, and a 48-inch slotting machine, for example, would not ordinarily be thought of as a tool of the portable type. The advent of electricity as a motive power, however, has brought some of its striking results into this field as well as into others of perhaps better known character, and has given to some of the heavier machine-shop equipments a flexibility of application which has widely extended their sphere of usefulness and has correspondingly simplified operations of hitherto awkward nature.

The possibility, through electric driving, of bringing the tool to the work instead of the work to the tool has, indeed, led to a degree of economy in the handling of material which, in one large engineering workshop, is the immediately striking feature of the place. An overhead electric traveling crane picks up a heavy slotting, or shaping, machine, or drill press, or other tool of required kind, carries it the length of the shop, if need be, to the work in hand, and as promptly takes it away after its mission has been accomplished, to operate upon some other piece of work, or to make room for some other tool. That portion of the shop floor commanded by the crane is one huge work table, slotted and grooved in all directions for temporarily bolting down the tools, and the equipment in its entirety and the method of handling it afford a splendid object lesson of evolution in shop practice.

No time is lost in carrying the heavy piece of work from tool to tool to be adjusted and fastened for each separate one; it is left in its originally allotted place, to be operated upon by each tool in turn, or, preferably, by several tools at once, as is often possible, with a degree of ease, rapidity and precision which invariably is impressive.

Leakages in Electric and Gas Plants

The irrepressible conflict between gas and electric lighting interests finds vent occasionally in unexpected directions. At one time it is the gas advocate proclaiming the dangerous nature of electric light wires as a frequent cause of all fires that are mysterious. At other times it is the advocate of electricity raising a warning voice against the earth-filtered, odorless illuminating gas, which, escaping from the leaky mains, enters our abodes undetected, and doubtless occasions all fires of which the source is not otherwise explainable.

The truth, however, is that the managers and directors of the various electric light and power companies and gas companies are much more alert to eliminating all kinds of suppressible leakage and other losses than the general public imagines. In both industries there is a large annual loss, more or less unaccounted for. In the gas industry a small percentage of this loss can fairly be attributed to actual leakage from the mains, and no expense is spared to minimize this loss by prompt and constant repairs and renewals. A larger proportion of the gas sent out, but not accounted for, may be properly attributed to defective meters, and, in the case of street lighting, to a greater consumption of gas in the lamps than is allowed for on the books, and so forth.

The total amount of unaccounted-for gas, that is, the difference between the amount recorded by the station gas meters and that recorded by the consumers' meters, varies in different places, but probably it does not exceed an average of 10 per cent. of the amount of gas generated, of which, perhaps, less than 2 per cent. may be properly charged to leakage at the mains. This rate of leakage in the larger cities amounts to about 500 cubic feet of gas per day.

The unaccounted-for gas loss is at least equaled by accounted and unaccounted-for losses in the supply of electricity from central stations, where it is known to range from 10 to 60 per cent. of the output. Comparatively little of this loss is, however, due to actual leakage of electricity from the conductors, especially where the wires are underground, since a serious escape of current very quickly makes itself felt in the operation of the system, and thus leads to prompt detection. The major losses are in the conductors themselves, in the core losses of the transformers, where transformers are used, and in the recording meters on the consumers' premises. Hence, strictly speaking, these losses are not unaccounted for, since the line and core losses are easily calculated.

Statistics indicate that in the case of gas and electricity supply the percentage of slow-running meters is largely in excess of fast-running meters. The loss from this source may perhaps amount to from 4 to 6 per cent. in the case of electric meters. It is, unfortunately, a fact that in numerous instances central stations of electricity supply are not equipped with recording wattmeters, and, consequently, have no check upon their losses.

Somewhat apropos of this subject it may be noted that the uses of electric light are not charged for light, but for electrical energy when recording wattmeters are used, or, in other words, for kilowatt-hours. It is, therefore, very much to the interest of the user to have lamps of high efficiency, but not perhaps equally so to the central station manager, who, if it were possible, at one stroke, to provide a lamp having double its present efficiency, would find half his occupation gone, and for this reason some timid station managers look askance and with misgivings upon any improved lamp efficiency. Such misgivings are unnecessary, since, almost without exception, experience has shown that advances of this nature lead to increased use of the commodity, and thus things equalize themselves. The Welsbach or Aner light was an instance of this, and the gas people, to their credit, be it said, were quick to avail themselves of it.

Standardizing the Power Plant

One of the most striking characteristics brought to light by the study of electric power plant design and operation in different parts of the world is the diversity of means employed to attain the same ends. The variety in generators and prime movers affords the opportunity for interesting comparisons of efficiency, maintenance, expense and behavior under every-day conditions of operation, but it is now coming to be recognized that economy is better served in individual plants by uniformity in apparatus and design than by installing a veritable museum of machinery when one or

two types would do the work in hand. The general run of new systems is now being designed with the idea of duplication in mind, but the most casual examination of the older plants now in operation plainly shows the need of improved machinery and of elimination of types of apparatus nearly obsolete.

This multiplication of forms is largely the result of the rapid developments in electrical machinery which have characterized the lighting and power industry since its earliest days, rather than any deliberate intention to secure a variety of apparatus more suited to the college laboratory than to the commercial central station. The mistake has been made in retaining the old machinery with the new, instead of disposing of it in favor of more economical designs.

A case in point is illustrated by a lighting, railway and power plant recently visited in a Western city of about 10,000 inhabitants. The boiler plant contained about 700 H. P. in equipment, and the engine room, 500 K.W. in engines and generators, as nearly as could be figured. Two of the boilers were of the latest water-tube type, while the other two were of the horizontal return tubular pattern, having a capacity about 40 per cent. as large as the former. The eight engines were all horizontal, single-cylinder, non-condensing machines, most of them being so old that the steam pressure had to be kept at 80 pounds instead of the 160 for which the boilers were designed, while the dynamos consisted of two direct-current 112-volt generators, one inductor alternator, two bi-polar railway machines, three Thomson-Houston arc machines and three small composite wound alternators belted to the engine. The dynamo room was lighted by enclosed arc, open arc and incandescent lamps; there were one marble and three wooden switchboards, while the steam piping was without the slightest flexibility or by-pass arrangements for use in time of trouble. The evening load was large enough to require the operation of every engine and generator that could be pressed into service, and the two attendants in charge of the machinery were kept moving from engine to engine without the slightest intermission in the intense nervous strain of preventing overheated bearings and breakdowns. Above the machinery the wiring ran through the wooden rafters in a network which threatened the life of any employee venturing aloft when current was on, and the condition of the plant, as regards the fire risk, was decidedly hazardous.

The opportunity for cutting down losses in this station is probably large enough to warrant the purchase of condensers, new compound engines and direct-connected generators to replace the present inefficient outfit. There is no reasonable doubt that the operation of so many small, separate machines of old design, would work out as far from economical when compared with the results which would be attained with a few large units. Electric lighting practice has now reached the point where the old direct-current open arcs can safely be replaced by alternating lamps; the alternating-current stationary motor has long since demonstrated its fitness for almost every work which can be performed by its direct-current prototype, and even the electric railway has been forced to consider the prospect of doing away with continuous-current motive power.

It is safe to say that one of the engine room attendants could be dispensed with if new machinery were adopted, or to put the matter another way, each man could easily look after twice the amount of apparatus in K. W. capacity than he can manage at present.

Floor space, already over-crowded, would be economized; the rewiring of the plant to a single fireproof switchboard would largely reduce the chance of a fire which would put the station out of business for a costly period, and the cost and inconvenience of repairs would certainly be greatly reduced by the adoption of uniform machinery and the storage of interchangeable spare parts. Operation would be simplified, the investment in high-pressure boilers would become no longer a source of loss, the steam piping could be made flexible at slight expense—in short, the entire plant appears to offer an attractive opportunity for the adoption of modern equipment.

These are days when every industrial manager sits down at his desk with the text of economy in his mind, and the production of electricity in central stations is just as dependent upon modern equipment for financial success as is the manufacture of shoes and clothing. The railways have found out that it does not pay to retain obsolete locomotives and worn out cars in service, and it is time that the owners and managers of electric plants applied the same lesson to their growing business.

According to official statistics, the total annual production of the coal of the world, exclusive of lignite, amounts to something over 700,000,000 tons.

Railways in China

THE first railway in China was built in 1897, and extended from Peking to Tientsin, a distance of 75 miles. It has since been extended to Shanhaikwan, an additional distance of 91 miles. From Peking there is a road to Tungtschu, a distance of 18.6 miles. The main road, however, is the Lu-han Railroad, extending through Pechili, Honan, and Hupe to Hankau, with a total length of 652 miles. There are a number of branches to this road. One of these starts at Tschongtingfu, extending to Tai Juanfu, the capital of Shansi, a distance of 155 miles. Farther south is the undertaking of the Peking syndicate, an English company. In northern China is the Kiao-chau-Tsinanfu Railroad, 186 miles long. Railroads have been planned from Peking to Kiachta and from Tientsin to Chinkiang, and a Belgian company has a concession to build a road from Honan south from the Yellow River. Other lines in China are the following:—Shanghai-Wusung, 12 miles; Canton-Fatschan, 18 miles; Shanghai-Nankin, 174 miles.

Sudden fires have sometimes started in chemical cleaning and dyeing works when the workmen drew the cleared woollen material from the bath. According to "Electrochemical Industry" it was found that when using benzine the woollen material in moving about became positively charged with electricity and the benzine negatively. On removing the material a spark discharge might take place and the explosive mixture of benzine vapor and air be ignited. By the addition of a small amount of oleate of magnesium to the benzine, however, the conductivity of the latter is considerably increased, and no charge can be stored up in it, thus avoiding any possible discharge through the woolen material.

The uses of the X-rays are many, and sometimes marvelous, in a certain sense; also, there are times when they greatly embarrass those subjected to them. It is reported that peculations were discovered some time ago in the Japanese mint, and some of the employees were supposed to have swallowed gold coins of small denominations. These coins were detected in the stomachs of the suspected persons upon testing them the aid of X-rays.

According to recent figures, water power to the extent of 238,000 H. P., derived from the Alpine districts, is used in miscellaneous French industries.

Interurban Electric Railways in the United States

By DAY ALLEN WILLEY

SOME of the Americans who visited the Berlin Exposition in 1879 enjoyed the novelty of riding in a car propelled by electric motors along a miniature railroad 1000 feet in length. It was not until five years later, however, in 1884, that the first street railway to use the electric current in the United States was completed in Kansas City, Mo. This, too, was largely an experiment, so that the era of the construction of the electrical railways in this country properly begins with the 13-mile line built in the city of Richmond, Va., by Frank J. Sprague in 1888.

Progress from that time on was rapid, so that in 1890 about 1300 miles had been completed in different cities by 144 companies, with 2900 motor cars in operation. The truly marvelous expansion of this method of transportation is shown by the fact that in ten years the mileage had increased to nearly 18,000, requiring nearly 51,000 cars, while the number of companies had increased to 971. To-day it is estimated by conservative authorities that fully two billion dollars have been invested in the construction of electric street and suburban systems, representing 20,000 miles, and probably no community of 15,000 in the country is without a motor car line.

After providing the people of the various cities with a network of routes by which to travel from center to suburbs, it was only natural that the railway builders should realize the need of suburban lines as well, and it is needless to say that the residence towns bordering on so many of the principal communities are due to the bonds of steel connecting each with the city of which it really forms a part. This work may be called the second stage in the development of the electric railway.

We have now arrived at the beginning of the third stage, which may eclipse even both of its predecessors in importance. The operation of what is known as the interurban electric railroad has demonstrated beyond question that it is not only practicable but profitable as well, offering a new and limitless field to the capitalist, the engineer and the contractor. While the trolley has been extensively used

THE SIEMENS & HALSKE MINIATURE ELECTRIC RAILWAY SHOWN AT THE BERLIN EXPOSITION IN 1879

A SECTION OF INTERURBAN TRACK, SHOWING AUTOMATIC SIGNALS CONTROLLED BY THE PASSAGE OF THE CARS OVER THE LINE

in the building of these railroads between cities, the inauguration of long-distance electric lines means a radical change in their construction from the plans usually followed in cities, and possibly the passing of the trolley, since the method of overhead transmission may be replaced by another system. It is not too much to predict that the new era of transportation will be a decided advancement on the present systems of electric propulsion, not only from the practical standpoint, but from the artistic point of view as well.

If a map of the United States were drawn to include the various interurban electric railways, it would be especially noticeable for the number which have already been completed or are under construction in New York State, in Southern Michigan, Ohio, Indiana, Illinois and Southern Wisconsin. Naturally the majority of the enterprises have been taken up as the extension of urban roads and terminate either within the limits of some important community or in its suburbs.

It is obvious that Chicago would

naturally be one of the centers of this development, and at present three of the larger interurban lines are connected with it,—the Chicago & Joliet, extending parallel with the drainage canal; the Aurora, Elgin & Chicago, and the Chicago & Milwaukee, now completed as far as Waukegan, Wis., a distance of 40 miles. Besides these, five other roads have been completed to points at least 25 miles beyond the city, and the majority will be extended to points in Wisconsin, Illinois and Indiana. From Milwaukee several lines radiate, and with the system operated within the city limits, comprise 240 miles of track. One of these extends south to Kenosha, leaving a gap of but 16 miles between its terminus and the end of the Chicago & Milwaukee Railroad. This extension is to be built during the coming year, forming a 90-mile system between the cities mentioned and providing them with three rail routes.

AN ELECTRIC LOCOMOTIVE ON THE BUFFALO & LOCKPORT RAILWAY. BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

The cities of Indianapolis, Terre Haute and Fort Wayne in Indiana; Cleveland and Toledo in Ohio; Detroit and Ann Arbor in Michigan, are also objective points for electric systems varying in length from 25 to nearly 100 miles, and in the majority of instances constructed to transport not only passengers, but express matter, freight and baggage as well. They are also equipped with mail cars. A conservative estimate of the amount invested in projects of this character in Indiana alone during the last two years places it at nearly $40,000,000, while the official records of the State of Illinois indicate that the mileage of interurban roads thus far constructed represents an outlay of fully $50,000,000.

In New York State the cities of Buffalo, Rochester and Syracuse may be included in the list of centers of this activity. Rochester is connected with nearly every town of importance within 30 miles of it by the electric car, while extensions are being built which promise to link it with Syracuse and Buffalo in the near future. The passenger can board a car in the center of the city and ride to the town of Sodus, a distance of 32 miles, without leaving his seat, and in another direction he can travel a distance of nearly 50 miles.

Buffalo and Lockport are connected by an electric system somewhat novel, from the fact that it is used almost exclusively for moving freight trains. It is equipped with electric locomotives specially designed for heavy service, and, with the exception of the method of transmitting current, is quite similar to the Belt line through the city of Baltimore.

The principal electric railway out of Syracuse has recently been completed to Auburn, a distance of 26 miles. It was constructed to compete with a branch of the New York Central system between the cities. This line is a notable instance of the ability to maintain a high rate of speed on heavy grades by using the electric current. In some places the ascents are as heavy as 9 per cent., while one of the grades, which averages $3\frac{1}{2}$ per cent. for the entire distance, is 1 mile in length. The overhead trolley is used. The track is laid with rails as heavy as in service on the ordinary steam road, and the bed is heavily ballasted with stone. It is calculated that the run can be made between the cities in less than an hour, stopping at the principal stations which lie along the route. The company expects to obtain its revenue from a population aggregating 165,000, and to carry freight as well as passengers.

Among the systems in Southern Michigan, already referred to, two

DRILLING FOUR RAIL ENDS AT ONE TIME FOR TRACK BONDING. POWER IS FURNISHED BY A GASOLINE ENGINE IN THE CAR

SOME TYPICAL INTERURBAN CAR INTERIORS

may be considered as representing the most advanced type of those using the overhead line for interurban service. They are the Grand Rapids, Holland & Lake Michigan, and the Lansing, St. Johns & St. Louis roads. The former connects Grand Rapids with the eastern shore of Lake Michigan, reaching the ports of Muskegon and Grand Haven. It consists of two branches, and while principally used at present for passenger traffic, is intended also to transport fruit to the lake ports and to Grand Rapids, as it passes through a section which produces a large quantity of fruit annually. Cars especially designed for this purpose are to be utilized.

The Lansing, St. Johns & St. Louis is being completed between the capital of the State and the town of St. Louis, almost directly north. It traverses two of the most thickly settled counties of Michigan, through which pass several steam railroad lines, and to a certain extent is their competitor. The completed section between Lansing and St. Johns, however, is securing such a large amount of passenger traffic that the promoters believe the road will be an extremely profitable venture. It is intended to extend it further south to form a portion of the network of interurban lines which terminate at Detroit, and will in a few years reach across the State to Grand Rapids.

One of the notable third-rail systems at present in operation in the United States extends between the suburbs of Chicago and Elgin, Ill. In the formation of the roadbed, the weight of the rails and other features, it bears a strong resemblance to the modern steam system, and the trains upon it are operated on a schedule of speed averaging nearly 40 miles an hour. The possibility of a much higher scale, however, has been demonstrated by tests made over the line in which a single car was run from one end to the other, a distance of 34 miles, in 35 minutes, a rate of over 58 miles an hour, including time in running slowly over thirteen crossings.

The Aurora, Elgin & Chicago line is constructed along a private right of way and not upon a public road, as is the case with many interurban lines. Two tracks have been laid upon a considerable portion of the roadbed, and it is intended to equip the line with double track throughout. In Pennsylvania a road is being completed which represents the most modern features of the third-rail system. It is intended to afford both passenger and freight service between the towns of Wilkesbarre, Scranton, Pittston and Carbondale, a distance of 35 miles.

ELECTRIC LOCOMOTIVE TYPES FROM THE GENERAL ELECTRIC COMPANY. BUILT FOR THE BALTIMORE & OHIO BELT LINE AT BALTIMORE

Owing to the topography of the country, Messrs. Westinghouse, Church, Kerr & Company, under whose supervision the road is being constructed, were obliged to solve some unusually difficult engineering problems. The methods followed in the building of the ordinary steam railroad were adopted, requiring a number of very deep cuts as well as a large amount of masonry and filling-in. On the section between Scranton and Pittston alone there are fourteen steel bridges, and at one point the tracks are carried over a steel viaduct 684 feet in length and 93 feet at its greatest height. Another viaduct near the Wilkesbarre terminus is 554 feet long. The rails are laid in rock ballast ranging from 1 foot to 2 feet in depth, the current-conducting rail being placed at the inner side of each track at the edges of the ties.

Provided with motors of 300 horsepower, each car can maintain an average speed of 50 miles an hour when carrying its full complement of passengers, but the speed frequently exceeds a mile a minute. Between Scranton and Wilkesbarre, a distance of approximately 21 miles, there are six stations. The time schedule provides for a run over this section in 40 minutes, including all stops.

A TRAIN ON THE AURORA-ELGIN-CHICAGO LINE

Current for the road is generated at Scranton. Transformers are placed in sub-stations at convenient points between the terminals. The passenger coaches will seat sixty people, each having smoking compartments to accommodate twenty-five. Combination cars for passengers and baggage have been provided, with seats for forty-two people. The Lackawanna & Wyoming Valley Railway, as it is called, is of unusual interest, not only because it represents the most advanced stage of American electric railway construction, but also because it is situated in a section of Pennsylvania which is already well provided with transportation facilities.

In the suburbs of Dayton, Ohio, the unique spectacle is presented of three transportation routes entering the city side by side—two using electricity and one using steam as a means of propulsion. They comprise a modern steam railroad, a waterway on which the boats are towed by electric motors, and an interurban trolley line. In an extensive area of territory they are competitors for freight traffic, but the annual reports of the com-

A ROCK CUT ON THE THIRD-RAIL LINE OF THE LACKAWANNA & WYOMING VALLEY ROAD

panies operating them show that the competition thus far has not diminished their average revenues. But parallel systems in which steam and electricity are employed for motive power are the rule rather than the exception, for, as already intimated, the majority of the interurban railways have not been constructed in parts of the country otherwise destitute of transportation facilities. The tendency has been to build them where the steam railroads are comparatively numerous.

One can now board a trolley car in the suburbs of New York and ride to Boston by this means, with the exception of only a few miles, and these will be spanned in the near future. The country through which this line passes is interspersed with a network of rails on which the ordinary steam locomotive is in service. This state of affairs is true also in New Jersey and Pennsylvania, where electric railways have been extended to connect Philadelphia and Jersey City, despite the fact that two of the principal trunk lines of the United States are in operation between these two cities.

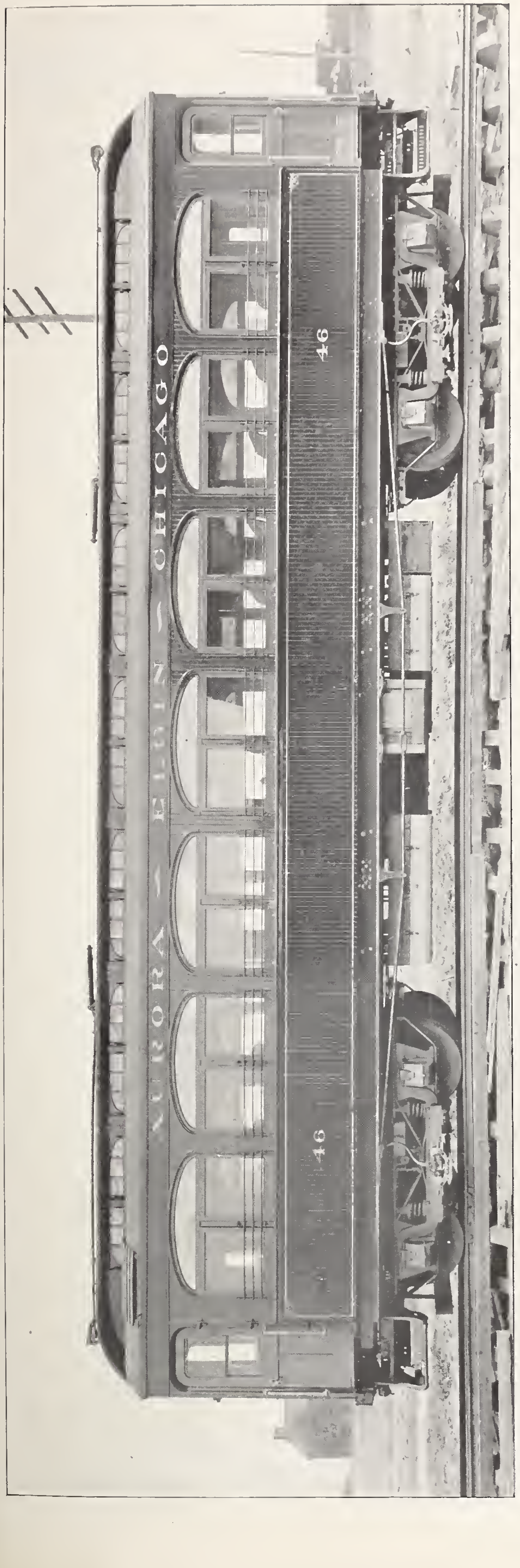
Statistics are available by which a comparison can be made between the cost of operating some of the routes maintained in the West. It costs the Union Traction Company, which owns one of the principal lines terminating at Indianapolis, a little over 50 per cent. of its entire earnings to maintain its train service. A recent annual report gives the percentage as 51.9. The Cleveland, Cincinnati, Chicago & St. Louis parallels the Union Traction Company's system. Although the former is one of the high standard railroads, its ratio of operating expense to earnings is 18 per cent. more than that of its competitor.

The Lorain & Cleveland Electric Railway is operated at actually less than 50 per cent. of its gross receipts yearly. It passes through a portion of Northern Ohio which is also reached by the New York, Chicago & St. Louis and the Lake Shore & Michigan Southern trunk lines. The last is known as one of the most economically managed systems in the world, its percentage of operating expenses to earnings being less than 65, but, as indicated, its electric competitor is maintained for 20 per cent. less.

The returns made to the Interstate Commerce Commission offer another basis for comparison. These returns show that while the average earnings per mile from passenger traffic on steam railroads in the United States in a single year amounted to \$1674, the average earnings of the interurban electric roads were \$3800 per mile, or nearly 2½ times as much, yet during the same period the average fare per mile received by the companies using steam was 2.003 cents while the electric companies averaged only 1.3 cents, indicating that they secured a much larger passenger traffic in proportion to their mileage than their competitors. The difference in the cost of operation has already been referred to, but when it is stated that some of the electric lines have actually earned 39 cents per car mile in a year from the freight business alone after deducting the cost of operation,—14.2 cents,—a better idea of their possible profit can be realized.

The remarkable increase in the mileage of city railways noted since 1890 is due largely to the fact that people have been educated to the value of the time saved by this means of transit from one part of a community to another. A large percentage of the patrons of trolley cars are those

A TYPE OF MODERN ELECTRIC RAILWAY PASSENGER STATION,—THIS ONE AT SCRANTON, PA.



A TYPICAL INTERURBAN CAR ON THE AURORA-ELGIN-CHICAGO LINE

who were accustomed to walk the mile or so between their homes and offices before the advent of the electric motor. The operation of interurban electric roads has also aroused a desire to patronize them among the population residing along the route, even if they have the facilities of a steam railroad.

A number of instances of this kind have been noted in the West, one being in connection with Cherry Valley, Ill., situated about midway between the towns of Rockford and Belvidere. About two years ago an electric railway was constructed between the last named communities, passing through Cherry Valley. The road parallels two steam railroads which also have stations at Cherry Valley. The passenger traffic obtained by the older companies in a year from the community, however, has not represented 5 per cent. of its total population. When the electric cars began running the company kept a record of the number of passengers from Cherry Valley who traveled over their line to the terminals. In a year it was found that the figures represented no less than one-third of the entire population.

The fact that electric cars can stop at cross-roads and other points in the rural districts undoubtedly caused them to be patronized largely by the farming class, who thus avoided a drive of perhaps 4 or 5 miles to the nearest railway station. An examination of the reports of some of these systems show a surprisingly large percentage of revenue from what might be called town-to-town traffic,—passengers picked up at road corners. In this respect the electric system has already become such a competitor of the steam lines in some portions of the country that the latter have been obliged to considerably reduce their tariffs in order to hold their own.

The Allis-Chalmers Company's Big Water Tank

THE Allis-Chalmers Company are having erected at their West Allis works, Milwaukee, what is said to be the largest elevated steel water tank ever built for a private concern. It is to form a part of the fire protection system, and will connect with the sprinkler apparatus recently installed throughout the buildings. The tank is 22 feet in diameter and 28 feet high, and will hold 100,000 gallons of water. The bottom of the tank is shaped like the bottom of a kettle, instead of flat, thus doing away with all dead pressure. A 10-inch pipe connects the tank with the sprinkler pipes. A steel coil encircles the superstructure, and jets of steam can be forced into the tank from the boiler house in the winter, to prevent freezing. The Chicago Bridge & Iron Works have the contract for its erection. Its extreme height of 164 feet above the ground level, added to the 148 feet elevation of the plant itself, makes the new structure visible for miles in all directions.

In erecting a large generator having a bed-plate to which the bearing pedestals were bolted, it was found that the shaft had no end-play. The erecting engineer, according to the Electric Club "Journal," therefore had the bearings taken out and faced off to give the shaft the proper amount of end-play, and reported to the factory that the machine had been shipped defective in this respect. An investigation brought to light the fact that the middle of the bed-plate had sagged, tilting the two bearings and bringing them nearer together, so that the space originally allowed on the shaft for end-play was taken up. The bearings were of the self-aligning type, so that this tilting had not interfered with the alignment of the bearings.

The Telephone System

By C. J. H. WOODBURY

From an Address before the Insurance Society of New York.

WHEN one removes the telephone from its hook and presently holds conversation with another person there is set up a train of operations possible only under concurrent action of science and handicraft, labor and capital. It may be worth while to trace some of the steps and the results towards which they are tending in modifying methods of life in business and personal affairs.

The writer will discuss the telephone system rather than the telephone as an instrument, an invention which is the most delicate piece of philosophical apparatus yet made by man, in that it is operated by less energy than any other device. The telephone system ministers to the needs of civilization in lengthening the potent life of mankind by the utilization of time. The telephone differs from all other electrical devices in that it is the only electrical appliance which does not require skill on the part of its users. It is equally the servant of all,—a polyglot; it speaks all languages and acts as a faithful messenger for the whole gamut of sounds.

The endeavor to communicate sounds by vibrations is not a new one. The string telephone was described by Dr. Robert Hooke in his book on "Ontacousticons" in 1667; but over a century earlier the transmission of vibrations to a diaphragm was applied during the second siege of Rhodes, in September, 1552, as related in the history of the Knights of Malta by Major Whitworth Porter. In this siege the Turks sunk shafts and drove galleries beneath the principal bastions. Gabriel Martingo, a Venetian engineer, in charge of the fortifications, excavated pits into which he inserted long rods, against the upper ends of which he placed a drum, and the vibrations of the earth in the tunnels made by the Turks were transmitted to this drumhead, which enabled the knights to determine their location and to sink countermines and destroy the advance of the enemy in this manner.

As an example of the wish to extend the limits of speech by means of electricity, reference is made to "Harper's Magazine" for June, 1867, where it is related, on page 131, that after a telegraph office was burned an instrument was temporarily installed in a carpenter's shop.

One noon the instrument clicked vigorously, and the carpenter placed his lips to the instrument and shouted, "Operator's gone to dinner; be back in half an hour," in the meantime receiving a shock on his lips, which served for remembrance.

This man had the desire, thought and conception in his endeavor to apply electrical apparatus to the transmission of speech, but he did not accomplish his purpose and failed to produce an invention.

Before tracing the operation of the events set in action by the removal of the telephone from the hook, let us follow the lines from the instrument to the switchboard in the latest type of telephone system. On the way from the subscriber's instrument, if any portion of the wires are aerial, protectors are inserted in the line for the purpose of defending the instrument against other electric currents imposed upon it by possible contact between telephone wires and those of electric light or power circuits, or even lightning, any of which would disarrange the delicate wires in a telephone, some of which are so fine that three and nine-tenths miles would weigh a pound. These protectors are so sensitive that they would shut from the telephone the battery currents used in telegraphing; and in like purpose the other ends of the lines at the telephone central stations are equipped with protectors to exclude the whole range of electric currents applied for lighting, power, the numerous signalling systems, and also lightning.

The form of apparatus used by the Bell telephone companies, who are especially careful in this regard, consists of a device inserted in each line, three-fold in its nature. The first element consists of a fuse made of an alloy which forms part of the circuit and is contained in a tube of vulcanized fiber. These fuses will deflagrate when exposed to currents of seven to ten amperes, the capacity of the fuse being varied according to the type of the apparatus.

The next element consists of a pair of small blocks of carbon, whose larger surface measures about 1 by $1\frac{1}{2}$ inches and is connected to the telephone circuit. The corresponding block of the pair of carbons is separated from it by a perforated sheet of mica and is electrically connected with the earth. A small cavity in one of the opposite faces of the carbon is filled with a button of solder, such as is used in automatic sprinklers, and which melts at 165° Fahrenheit.

The distance between these carbons is such that electricity at 350 volts will pass from the carbon connected with the telephone circuit across this space to the opposite carbon and thence to the earth, thereby relieving the telephonic apparatus of electric tension exceeding 350 volts.

Thus, if the foreign current exceeds the carrying capacity of the tubular fuse, its deflagration opens the circuit at that point. If, however, it is less in volume than the carrying capacity of the fuse, and over 350 volts tension, it leaps across the thin space separating the carbons, and thence passes to earth. The resistance of the tiny arc in the space between the carbons is sufficient to slightly warm the carbons and cause the fusible metal to flow from its recess and fill the space between the carbons, thus establishing a conductor of low resistance to earth.

This diminished resistance generally causes a sufficient increase in the current imposed upon a line to deflagrate the tubular fuse and open the circuit, if it did not do so on the first occurrence of the contact which imposed the foreign current on the telephone circuit.

In order to protect the fine wires of the telephonic apparatus from injury by currents which are too small to operate the tubular fuse, or of too low tension to pass to earth through the carbon cut-outs, a third element, known as the heat coil, is employed. In this device a fine German silver wire, which forms a part of the telephone circuit, will be heated by a current of one-sixth of an ampere to a temperature sufficient to release a conductor ordinarily secured by fusion solder, and pass the current to earth.

TELEPHONING FOR THE FIRST TIME FROM NEW YORK TO CHICAGO ON OCTOBER 18, 1892, WITH PROFESSOR ALEXANDER GRAHAM BELL AT THE INSTRUMENT

This device is not used at the subscriber's end of the line in those modern types of telephonic apparatus in which the circuit is normally open, except when the telephone is in use, because heat coils are an interference with the best conditions of telephone service by adding to the electrical length of the line. If a foreign current came in contact with the telephone line at a time when the instrument was in use, it would produce noises to an extent as to absolutely prevent the transmission of speech, and the user of the telephone would naturally place the receiver on the hook and thereby open the circuit.

The results secured with this protective apparatus have been so successful as to establish in the Bell system of telephony, after an experience of many years, conditions of immunity against mishaps to the apparatus resulting from foreign currents and lightning. A telephone office thus equipped appears to be, like a locomotive, the safest refuge in a thunderstorm. Nothwithstanding the number and range of location of telephone central stations, it has not been possible to obtain information of any injury by lightning to any person in such a place.

Following the course of the lines from the subscriber's instrument, the aerial wires are of copper treated by the hard-drawn process, as commercial copper is too ductile and has but little resiliency, not returning to its original length when stretched by a load of snow or by a low temperature.

Hard-drawn copper might be classed as one of the modern inventions which the ancients stole, if the accounts of early implements may be accepted, but investigations showing that bronze had been supposed to be copper have absolved them of anticipating the work of Mr. Thomas B. Doolittle. He produced hard-drawn copper by omitting the annealing during the latter part of the process, and obtained wire which retains the electrical conductivity of commercial copper while its tensile strength is doubled, and it is also divested of the tendency to continually stretch under its own weight.

The substitution of hard-drawn copper wire for iron wire, which was formerly used, has increased the limit of telephone conversation about four times, and by its better conductivity has diminished the waste of electricity in telegraphy, electric lighting and transmission of power, or, in other words, has extended the limits of their application.

For local use, the wires used in telephony are generally one-tenth of an inch in diameter; for long-distance lines wires about one-sixth of an inch in diameter are used. The contact of these wires with those used for lighting or power, to which reference has been made, is not the only difficulty, for the mere proximity of other wires conducting powerful currents will, if they are of changing polarity, produce by induction sympathetic currents in the telephone wires, which, acting on the telephone, will occasion noises which at times interfere with the transmission of speech, furnishing examples of wireless telephony which are impediments to the usual service.

This interference by induction is minimized by transposing the wires on the cross-arms, the result being that these disturbing elements will counteract each other. Underground cables are arranged in twisted pairs so that they are immune to inductive influences.

An aerial line is subject to the attacks of all kinds of disintegrating conditions, decaying poles, falling branches, etc., but it would be as unfeasible to make a pole line equal to withstanding the stress of all weather as it would be to make the rigging of a vessel equal to resisting the impact of all storms. During a recent winter the destruction of aerial telephone, telegraph and electric light lines in New England was estimated to be greater than the loss by shipwreck on the New England coast.

Every possible precaution must be taken to avoid contact between high-tension and signalling lines, rather than to rely upon protective devices to defend the plant against physical injury, because the operation of a protector suspends the service over that line for the time being. At cross-overs it is preferable that the high-tension line should be above, as its wires are of larger diameter and generally fewer in number than those of the signalling line. Whenever high-tension and signalling wires approach one another every precaution should be taken to provide against possible contact by the use of heavy material in construction, particularly guys and braces to the poles.

The aerial lines pass from the poles into underground conduits in the congested parts of cities, passing from the mishaps of storms and crosses to other difficulties which are largely those of greater expenditure and electrical problems.

Conditions of safety and good service require that an underground telephone system should not also include lines of electric lighting and power circuits, serious mishaps having occurred in the few instances where the attempt has been made to place these diverse types of electric circuits adjacent to each other in the same underground system.

The underground system is older than the aerial system of electric conductors in applied electricity, for a portion of Morse's telegraphic inventions consisted of methods for burying wires, but the first seven miles of a line out of Baltimore, which were laid underground in lead pipes placed in a plough furrow, were inoperative.

A foreman on the work, because he could not bury the wires along the stone viaduct at Relay Station, placed them on poles, with cattle horns from a neighboring slaughter house as insulators. The expedient proved so successful that the remainder of the line to Washington was built in the same manner, the first portion being also reconstructed.

Underground conduits for telephone cables consist of groups of continuous ducts, generally three inches in diameter, and are made of vitrified tile, cement monoliths reinforced with iron, or creosoted timber. Every few hundred feet these conduits lead to an underground chamber, which provides a means of access to the cable from above for the purpose of joining the ends of sections of the cables together, installing branch lines, making repairs, etc. The underground cables generally consist of about 200 twisted pairs of wires, insulated with paper, the whole being covered with a lead sheath.

The electrical difficulties of telephoning through underground conductors were at first prohibitive in their nature, but improvements enabled this to be done later, although in the face of conditions which rendered 1 mile of underground the equivalent of 52 miles of overhead wire. In the modern cable 1 mile of underground is the equivalent of 28 miles of overhead copper wire one-sixth of an inch in diameter, or 12½ miles of overhead copper wire one-tenth of an inch in diameter.

The conditions of underground operation are so severe that on long lines it is necessary to pass around intermediate cities in order to avoid the installation of an underground system. In the suburbs of large cities are switching stations which provide connections whereby messages are sent by branch lines direct into the cities, or are permitted to continue on the main line to places beyond.

The terminals of the underground cable at the telephone central station emerge from their lead sheaths and are spread out upon a large iron rack, known as the distributing frame, where the insulated wires are equipped with protectors for the same purpose as those at the sub-

scriber's instrument; the wires are changed from the order in which they are received from the cable to another classification, and thence to a similar rack, called the intermediate frame, where they are grouped to the individual operators. This latter arrangement may be changed from time to time, as the number of telephones to which an operator can give attention varies according to the character of the service; that is, a business house conducting much of its affairs by telephone uses many messages a day and requires more of an operator's time than a residence, with its infrequent use of the telephone.

The grouping of the use of the telephone may well serve as the basis of a sociological study of the habits and customs of a community, but for studying the conditions of service for which provision must be made the number of communications each hour of the whole day is taken from time to time, and the result is plotted in a diagram whose hills and valleys indicate the relative load of service on the system.

In all cases, the night use between 7 p. m. and 7 a. m. is a small proportion of the day use, and while these calls are largely of the important nature of emergency calls for fire department, physician or police, yet in number they are only slightly over 1 per cent. of the calls of the whole twenty-four hours. But the calls during the day begin to increase suddenly at some hour in the forenoon, after the morning mail has received attention, and approaches the congestion limit in the middle of the day, falling off suddenly as offices are being closed and resuming activity in the larger cities late in the afternoon, when arrangements for dinner or theatre are being made.

In the West the general business day is longer than in the East, while in New York the plotted diagram indicates by the short duration of the extremely busy period that many might avail themselves of Charles Lamb's excuse to the bureau officer in the East India Company's office, and make amends for being late at their desks in the morning by leaving earlier in the afternoon.

The short time taken for lunch, or, indeed, its omission, in New York does not make a sufficient break in business affairs to produce a depression in the curve, while in another city the depression is so great as to suggest a noon-day dinner at home, followed, perhaps, by a nap of forty winks.

The total amount of telephone line of the Bell system throughout the United States averages 3.29 miles per line to each telephone instrument. Excluding the long-distance lines, 55 per cent. of this is underground.

When a person calls up another telephone, the average line-plant at his disposal is 6.58 miles; truly "it is cheaper to talk than to travel."

The function of the switchboard is merely to place the ends of the wires from one telephone in electrical contact with those of any other telephone in the exchange, with suitable signals for calling the operator and the person addressed. This system has been so amplified until one human voice can reach to districts including considerably more than half of the population of the United States; and the interlacing has been so complete that its service reaches the smaller villages.

The first switchboards were based upon the telegraphic device of placing any two of half a dozen lines in contact, the further development merging the principle of the annunciator, used in hotels or in passenger elevators, in which a falling target, or shutter, called in a like manner the attention of the operator. With the needs of the patrons the switchboard grew; new features were added and old methods were discarded; every improvement meant an abandonment of former devices.

In these new switchboards the dropping shutter has been supplanted by the flash of a lamp to signal the operator. The turning of a crank to generate a current for moving a shutter is no longer necessary; when the subscriber removes the telephone from the hook he is ready to begin. Galvanic batteries are no longer installed at the subscriber's equipment, but the whole of the electric energy is supplied by storage batteries at the telephone central station.

When the subscriber removes the telephone from the hook, which is merely an electric switch arranged to be operated in this manner, without conscious effort on the part of the subscriber, a small electric bulb, about the size of the end of a lead pencil and imbedded in the switchboard, becomes illumined with an opalescent glow which attracts the attention of the operator. The operator inserts a plug at the end of flexible conductors into a small socket perforating the face of the switchboard just below the electric light, this corresponding to the telephone of the subscriber, and the socket guides the plug to contact with the ends of the wires from the subscriber's telephone. The insertion of the plug in the socket also extinguishes the signal light.

A touch upon an electric key places the operator's telephone in circuit with the telephone of the subscriber, who hears the inquiry for the number wanted. On receiving directions, the operator inserts the plug at the other end of the same flexible conductor into the socket corresponding with the telephone wires of the party desired, and this lights one of a pair of signal lamps imbedded in the table projecting from the front of the switchboard.

If, however, the operator hears a click on inserting the second plug, he knows that this is a signal that the desired line is in use elsewhere on the board and the line is reported as being "busy." It is more personal trouble for an operator to report a line as being busy than it is to complete the connection.

When the party called to the telephone removes the instrument from the hook to receive the message this light on the table becomes extinguished. After both persons have finished talking, the hanging of their telephones on the hooks flashes the pair of lamps on the table, which glow until the operator, perceiving the signal, pulls both of the plugs from their sockets.

If, instead of a subscriber at the same switchboard, one is desired at another exchange, the proceeding becomes more complicated, and many of the arrangements of the modern telephone central station and methods of administration are designed to provide for this extension of the service.

When a call is received such that the operator cannot reach a line directly to the desired telephone, the call is transmitted by an office line to a special operator at another switchboard, where it is noted on a memorandum blank and the time automatically recorded by means of a clock registering stamp; then the call is transmitted by trunk lines to the desired telephone central station, or, it may be, to some station which can reach the desired subscriber. In some instances it is necessary to transmit the message through a greater number of telephone offices, each one building up the line by additions, and every operator also keeping, by means of the time stamp or memorandum blanks, a record of the hour and minute of each step from the initial call to the final termination of the conversation and the release of the lines. These memorandum blanks are compared by clerks and must balance as in other book-keeping, and form the authority for the charge for the service.

In some instances, where there is a great load of service on long-distance lines, the communication from one central station to another by the operators for the purpose of obtaining

the desired party at the telephone is carried on by telegraphing over the telephone lines; for there are methods by which this can be done without interfering with the transmission of conversation at the same time on the identical wires, these lines branching near their terminals, where each class of electrical currents is transmitted to its proper instrument, whether of the telegraph or the telephone system.

A telephone switchboard is an exception to general forms of construction in that the cost per unit increases at a greater rate than the enlargement. This is due to the fact that the operator who receives a call from a subscriber must be able to reach the terminals leading from the switchboard to any other telephone, or to the switchboards at other stations, and, therefore, each set of telephone wires must have as many sockets and branches as there are operators' sections at the switchboard.

For example, in a small switchboard with two operators' sections there would be two sets of such branches and sockets for each telephone line, while in a large switchboard with fifty operators' sections there would be fifty sets of such connections for each telephone line instead of two sets mentioned in the first instance, the number of this class of connections multiplying twenty-five times for each telephone.

This increase of complication of detail growing upon itself would reach a prohibitive cost in large cities had it not been found feasible to depart from the original plan of one central telephone station in each city, and to introduce a modification by apportioning large cities into telephone districts, each with its telephone station connected to the others by numerous trunk wires.

There are other precedents in construction where an increase in size adds disproportionately to the cost; as, for instance, bridges, where the expense of a larger span is disproportionately greater than that of a smaller one of equal strength; in a like manner large pipe organs cost more per unit of capacity than smaller ones.

A telephone switchboard is a marvel of complexity of detail in extreme contrast to the simplicity of operation, and no one person can have the repute of its design, it being one of the few inventions developed by the concerted efforts of many experts working together for a purpose.

The mechanical intricacy of the modern switchboard may well be appreciated by the fact that even with present methods of special machinery and the organized application of skilled artisanship, it requires as long to make and install a large switchboard as it does to build and equip a merchantman, from one to more than two years, while the cost of the central station plant may reach $1200 per foot of length for the larger switchboards, and perhaps half that cost per foot for a switchboard adequate for a city of 50,000 inhabitants.

These central station costs are a small detail of the whole cost of the system, although it represents the greatest concentration of value and forms the vital part of the whole exchange.

There is an exaggerated opinion of the damageability of a switchboard by water, and while it is perfectly true that it must be thoroughly dry for practical operation, yet switchboards have been thoroughly wet and restored to good service by drying out. It is the general custom to provide waterproof covers for switchboards as well as for generators and motors whenever it is thought that there is any hazard of a water damage due to fire in other parts of the building, which might cause an interruption in the service.

One of the floating statements which probably originated in the head of some one set to the task of filling a funny column, runs to the effect that a glass of water would cause $1000 damage in a switchboard, this statement being absolutely false.

When a switchboard is started in the service, the elements of its active demolition begin; repairs and adjustments are necessary, extensions are needed for increased capacity, wear and tear has been outclassed by the more iconoclastic depreciation from subsequent invention, and in a few years the old board becomes obsolete and the expensive apparatus is burned for the intrinsic value of the copper which it contains.

The telephone business, in its complications on the one hand and its close relations with the needs of its patrons on the other, is one requiring active zeal. As a certain French prisoner in the Bastile could always see an eye at a hole in an upper corner of his cell following his every movement, so, with as vigilant, although more agreeable an espionage, there is always an ear waiting at the office end of a telephone line to take the directions of the subscribers in giving service.

Under American conditions the equipment of the plant and its attendance must be adequate enough to give practically instantaneous service at all times, even though the demands at night are but slight in comparison with the requirements of the day.

The striking feature of the two great applications of electricity which are used by the public, the street car and the telephone, is that, however complex their mechanism, their use is extremely simple. There is, however, no premium on ignorance in the use of the telephone, either by subscriber or operator.

It has been a matter of slow growth for the subscribers at large to use the telephone in the best and simplest manner, that is, to speak clearly rather than loud, and to avoid the use of unnecessary words in calling for the number wanted. Operators are prepared by a short course in a special training school which differs from other institutions of learning, except West Point and Annapolis, in that they are under pay during the period of tuition.

The result of such systematic work in connection with improved apparatus in New York has reduced the time of making complete local connections during the last five years 3.9 seconds, which may appear a short time to any one except when waiting at a telephone,—or looking at a gun,—but this small amount of time, when applied to all the telephone connections of the Bell system in the United States, amounts to 10,098 hours a day saved of the subscribers' time, or about 3.9 years in eight-hour days. The saving of time in disconnections, largely owing to the common battery switchboard signalling the operator by lights rather than shutters, enables the lines to be released, when a conversation is at an end, 3 2-3 times as rapidly as formerly, this being of great advantage to the subscriber in making repeated calls.

This vast system provides for 9,322,951 calls per day, or nearly 2,500 calls a year originating at each telephone, and this means that an equal number of calls are received on the average telephone; each telephone, therefore, is in use, on an average, 5000 times a year. Why wonder, then, that these conversations, concentrated for the most part in the middle of the day, sometimes interrupt, and "the line is busy; please call again."

This interruption has been largely diminished of late years; first, by the use of two telephones by the subscriber, one being omitted from the telephone book, so that it is not subject to interruption by calls, and being therefore always free for use.

The second step in the development of the use of the telephone is an example of the modern principle of the subdivision of matters in the conduct of business affairs, each element being attended to by one excelling in that branch. In telephony this is done by concentrating the lines from the sev-

eral telephones in an establishment to one desk, where, under the service of a skilled attendant, the desired connections are obtained.

When telephone central stations were first established the names and positions of the subscribers on the switchboard were known to operators with good memories; but an epidemic of measles occurring in a town equipped with telephones, a physician on the board of directors of the telephone company viewed with alarm the possible condition of affairs if more than two of the four operators should be taken with the measles, and proposed therefore that the subscribers should be numbered.

His associates demurred, as they were of the opinion that the subscribers would give up their telephones sooner than submit to the indignity of being known by number, but in view of the contingency of the service being paralyzed, they finally yielded, and to the surprise of all, the new arrangement was cheerfully accepted by the subscribers, who appreciated the improvement in the service which resulted from the change.

Essential as the telephone now is to the conduct of affairs, no one can state, except as a general principle, why a person subscribes for a telephone. While a large town uses more telephones than a small one, the ratio of telephones to population differs materially in various places to an extent beyond what may be attributed to the personal energy of those in charge of local affairs; and in a like manner the relation of the number of telephones to the number of horses, electric lights, business houses, assessed valuations, or any other of the details of census enumeration, fails to afford any basis of close comparison.

However, there are several lines of general similarity which cannot be tabulated in the logic of numbers. Where highways are bad, there is a large amount of toll line telephone traffic. A hilly town uses far more telephones than a similar one on flat territory, and in some particulars one in a warm climate appears to give more patronage than a similar town in a cool climate; all of which shows that there is force in the injunction, "Don't travel; telephone."

The telegraph is not adapted to the transmission of the Chinese written language, and messages are necessarily translated into some modern language, and after receipt rendered back into Chinese. The telephone can be used by Chinamen who understand each other's dialect, of which there are about 75 varieties in China. There is a Chinese switchboard in San Francisco at which the operators must know the four principal dialects of the provinces which furnish the immigrants to this country.

As an example, the sign for "Telephone Office" can be read by any Chinaman, but the pronunciation would be different, as noted by examples from two of the leading dialects. In this respect it is comparable to Arabic numerals, which can be understood by all civilized nations, although read in far different words.

When a person uses a long distance telephone, a large amount of property is at his exclusive service; for instance, in speaking from Boston to Omaha, as one business firm does every morning, the value of the apparatus at their disposal is, at the present price of copper, over $283,000, while it requires the service of nine operators at the switchboards at various points along the line.

The weight of this copper is 1,131,000 pounds, or 565½ tons, and the wonder is not in the fact that a human voice can cause this immense mass of metal to vibrate in unison, even to the delicate touches of tone, which determine the individuality of one voice from that of another, so much as it is in that the telephone is so delicate that it can catch these vibrations and transmit them into speech.

In order to make every feasible provision for the permanency of the telephone service, the buildings erected by the telephone companies are, with the exception of a few with mill floors, entirely of fire-proof construction, and the designs are made especially with a view to obtaining stability under heavy loads and to afford resistance to fire. They are equipped with subsidiary fire apparatus, and the windows opening towards exposures are provided with fire-shutters.

In smaller towns, where special telephone buildings are not warranted and it is necessary to lease space for central stations, the utmost care is exercised to select the best buildings available for the purpose, and these are generally of that type so well known in small towns, where one side of the front entrance of the first story is occupied by a national bank and the other side by a savings bank or post office.

There is a general inspection of central station property which includes reports on general order as well as on matters pertaining to the service and the conditions of the electrical apparatus. In addition to the night watchman's patrol of such properties, notwithstanding the constant occupation of the operating room, there is a constant supervision of the central station apparatus against all disarrangements, equal in the larger central stations to an inspection of the plant every twenty minutes.

Wires are placed underground in cities, some of the apparatus is in duplicate, reserve portions are stored at convenient points, and the operation of the whole plant is under constant supervision. The electrical apparatus is frequently tested, inspectors patrol along the route of aerial lines, trials of service are made at the subscribers' instruments, in addition to electrical tests made from the central station without the subscribers' knowledge; even the electrical condition of the earth, as modified by the return currents of the electric railroads, is measured. All of these initial conditions and precautions of operation for the purpose of maintaining the permanency of the service have also reduced the fire losses on these properties to a nominal amount.

In other ways than refraining from having cause to make claims, the telephone has proven a most efficient ally of the underwriters' interests, for each instrument is a fire alarm, and in many towns the only fire alarm, is always ready to transmit emergency calls to the fire department, the police, or other help, in addition to the ordinary commercial and personal uses of the instrument.

The telephone habit is causing subscribers to use their telephones a greater number of times each day, and circumstances cause new uses which in turn become grafted onto the system. A few years ago, when the steamship "St. Paul" was stranded for a few days on the New Jersey coast, a man rowed out to the vessel with a telephone set attached to a new twisted pair of water-proof insulated wires, which served as a submarine cable, connected a telephone line on shore, and officers and passengers used the line until the liner was pulled into deep water and finished her voyage.

From this it was but a step to the present custom of connecting steamers by telephone while they are lying at dock, this having possibly been anticipated by the practice of connecting fire-boats by telephone when they are moored.

In the West, express trains are frequently connected by telephone at stations where there is a stop for a few minutes; and the trolley cars of long lines in Ohio have telephone booths. The cars of the funicular railroad on Mount Tom, near Holyoke, Mass., are equipped with telephones, connected by sliding contacts to a pair of wires at the side of the track, so that the motormen on the two cars can communicate with each other.

Railroads, particularly trolley lines, are largely managed by telephone, and

the installations at large terminal stations are on an extensive scale. Wrecking trains are equipped with a trolley line along the right of way and communication established with the headquarters of the company.

Business meetings and conferences are held by means of telephones which are joined together in such a manner that the whole number, instead of merely any two, can hear what one says. The board of directors of a Chicago corporation has members also at Milwaukee, St. Paul and Detroit, and meetings are frequently held with these men at their telephones taking part in the proceedings. At presidential conventions, a person near the stage telephones an account of the proceedings in a low tone, and this is repeated by another in a neighboring telephone station, where the wires are connected to a number of telephones, these messages being repeated in a like manner at each change until they extend wherever there are telephone lines; at various points the information is taken down by stenographers.

In hotels the telephone is used for calls from rooms to the office, obtaining quicker and more accurate service than can be secured by waiting for a bell boy, by whom the message may be forgotten or distorted. These room telephones can also be used throughout the general telephone system.

Oaths are administered over the telephone; it is against the rules of the company to utter them. Threats are made from the safe vantage of a sound-proof booth, and lawyers have been at variance as to alleged libels in the same manner. That lovers woo and swains propose over the telephone is an every-day remark, but a young man in Muncie, Ind., had some difference with a miss, and was shown the door with the injunction never to call again. Asking permission over the telephone to call again, her reply was to fire three revolver shots into the transmitter, so that the young man had good cause to remember that absence of body was preferable to presence of mind.

Telephone lines penetrate mines, extend through air locks of tunnels and caisson foundations; they ramify through extensive manufacturing establishments and form part of the equipments of vessels; they accompany the advance of armies, and keep the commander in communication with the firing line. In short, the applications of the telephone are becoming more extended as the emergency of yesterday becomes the precedent of to-day.

The electrical transmission of speech and its instantaneous reply is the last step in the progress of modern enlightenment in that concentration of effort and result which reaches every phase of life in its modification of commercial relations between individuals isolated from each other's presence.

Standard Abbreviations

THE standardizing of abbreviations, symbols, punctuation, etc., in technical papers, has been under consideration by a committee representing the four large national engineering societies. The members of this committee are Chas. W. Hunt, of the American Society of Civil Engineers; D. S. Jacobus, of the American Society of Mechanical Engineers; Jos. Struthers, of the American Institute of Mining Engineers, and Cary T. Hutchinson, of the American Institute of Electrical Engineers. The following recommendations have been made by them:—

1. Use abbreviations only after nouns denoting a definite quantity. Example:—"The power plant has a capacity of 10 h.p.," not "10 horse power;" but, "The capacity of the plant, in horse power, is ten."

2. Do not abbreviate abstract or descriptive words. Example:—"horizontal return tubular boilers," not "h.r.t. boilers."

3. Use lower case characters for abbreviations. An exception to this rule may be made in the case of words spelled normally with a capital. Example:—"B.t.u." and not "b.t.u." or "B.T.U." (British thermal unit), "U.S. gal." (United States gallon), "B. & S. gauge" (Brown & Sharp gauge).

4. Use a period after each abbreviation. In a compound abbreviation, do not use a space after a period. Example:—"i.h.p." and not "i. h. p." (indicated horse power).

5. Use a hyphen to connect abbreviations in cases where the words would take a hyphen if written out in full. When a hyphen is used, omit the period immediately preceding the hyphen. Example:—"3 kw-hr." and not "3 kw.-hr." (3 kilowatt-hours).

6. Use all abbreviations in the singular. Example:—"17 lb." and not "17 lbs." (17 pounds), "14 in.," not "14 ins." (14 inches).

7. Never use "p." for "per," but spell out the word. Example:—"100 ft-lb. per ton" (100 foot-pounds per ton); "60 miles per hr." (60 miles per hour).

8. Use decimals as far as possible, in place of vulgar fractions. Example:—"1.25 ft.," not "$1\frac{1}{4}$ ft."

9. In general, spell out an adjective qualifying the name of a unit. Example:—"Boiler h.p." (boiler horse-power). The exceptions to this rule are:—"i.h.p." (indicated horse power), "e.h.p." (electric horse power), "b.h.p." (brake horse power), "e.m.f." (electromotive force), "m.m.f." (magnetomotive force).

10. Use "Fig.," not "Figure." Example:—"Fig. 3," and not "Figure 3."

11. In all decimal numbers having no units a cipher should be placed before the decimal point. Example:—"0.32 lb.," not ".32 lb."

12. In the notation of large numbers, use "en" spaces instead of commas. Example:—"1 520 125," not, "1,520,125."

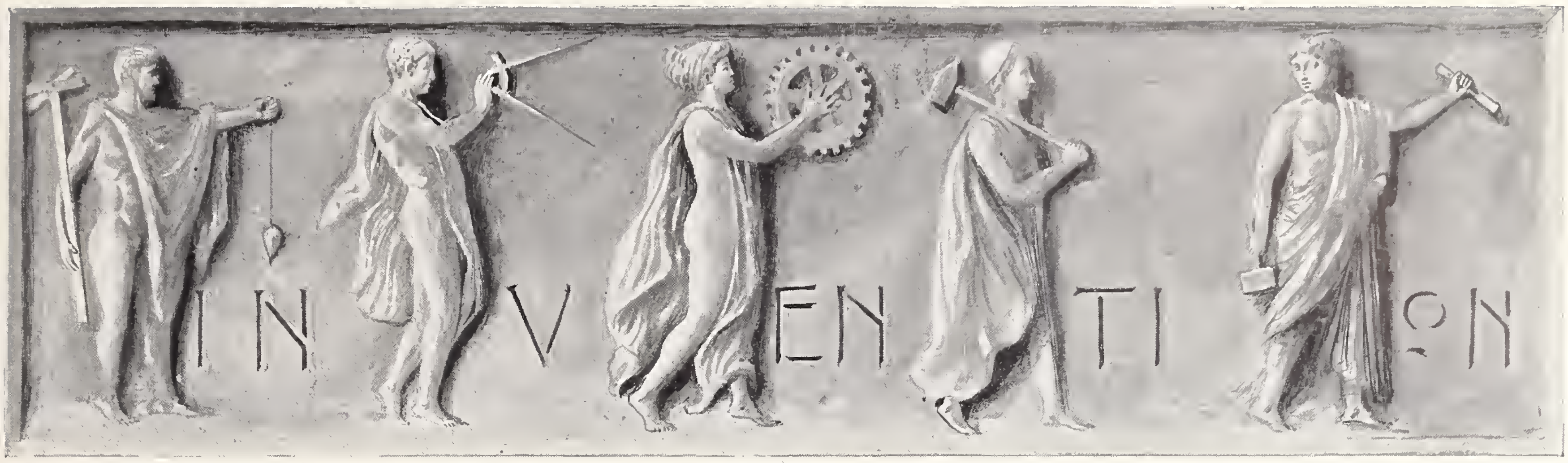
13. Use the word "by" instead of "x" in giving dimensions. Example: "8 by 12 in.," not "8 x 12 in."

14. Never use the characters (′) or (″) to indicate either feet and inches, or minutes and seconds as periods of time.

The following forms are given as illustrations of these rules, and are recommended to be used:—

Name.	Abbreviation.
Inches	in.
Feet	ft.
Yards	yd.
Miles	spell out.
Pounds	lb.
Grains	gr.
Tons	spell out.
Gallons	gal.
Meters	m.
Millimeters	mm.
Centimeters	cm.
Kilometers	km.
Kilogrammes	kg.
Grammes	g.
Milligrammes	mg.
Kilogramme-meters	kg-m.
Meter-kilogrammes	m-kg.
Seconds	sec.
Minutes	min.
Hours	hr.
Linear	lin.
Square	sq.
Cubic	cu.
Per	spell out.
Fahrenheit	fahr.
Centigrade	cent.
Percentage	% or per cent.
Volts	spell out.
Ohms	spell out.
Watts	spell out.
Kilowatts	kw.
Kilowatt-hours	kw-hr.
Watt-hours	watt-hr.
Amperes	spell out.
Brake porse power	b.h.p.
Electric horse power	e.h.p.
Indicated horse power	i.h.p.
British thermal units	B.t.u.
Gramme-calories	g-cal.
Kilogramme-calories	kg-cal.
Magnetomotive force	m.m.f.
Electromotive force	e.m.f.
Revolutions per minute	rev. per min.
Circular mils	cir. mils.
Miles per hour per second	miles per hr. per sec.
Candle-power	c-p.
Watts per candle-power	watts per c-p.
Mean effective pressure	spell out.
High pressure cylinder	spell out.
Diameter	spell out.

Milan, Italy, is to have an exposition, to open in April, 1906.



Electrical and Mechanical Progress

Railless Electric Roads in Germany

CONCERNING trackless trolley omnibus lines in Germany, to which reference was made in these pages last month, Consul Chas. L. Cole, of Dresden, in a recent report says that there are two in the vicinity of Dresden,—the so-called "Haidebahn," connecting with an electric tramway terminus at the outskirts of the town, and the "Koenigsstein" road starting from Koenigsstein, a town lying on the Elbe about 12 miles above Dresden. A large proportion of the passengers carried by both lines are tourists or Sunday strollers.

The Haidebahn covers a distance of 3.1 miles. Wagons run every half hour, the fares being 10 pfennigs (2.38 cents) for the shortest ride and 20 pfennigs (4.76 cents) for the full distance. The Haidebahn runs over a slightly undulating road, while the one at Koenigsstein covers about 2 miles of hilly highway. The speed of coaches varies considerably with the slope of the road, not, it seems, because of a lack of motor force, but for the sake of the comfort of passengers and the reduction of wear and tear on the machinery.

It seems that neither of these two lines has proved a marked success from a financial point of view, partly because located at points where the travel is sparse, but mainly because of the expense in operating. The electric energy required to move cars over dirt roads exceeds by 100 per cent. the power necessary to draw cars over rails.

A somewhat similar enterprise is mentioned by Consul Joseph J. Langer, of Solingen, Germany, the line in that case operating between Monnheim and Langenfeld,—about 2½ miles long, with two short branches for freight service.

The Bristol Thermometer Thermostat

A NEW instrument known as a thermometer-thermostat, since it is a combination of both devices, has been put on the market by the Bristol Company, of Waterbury, Conn., to meet the demand for an instrument that will give correct indications of the temperature of the atmosphere, gases or liquids at all times, and also serve as a thermostat to make electric connection at any predetermined limits of temperature for the purpose of operating controlling apparatus, alarms and the like.

Fig. 1 is an external view of the instrument, which is provided with a six-inch scale graduated in degrees Fahrenheit. The construction and capabilities of this instrument will be best understood by referring to the interior view, Fig. 2, in which *A* is an arm pivoted at the lower portion of the case, terminating in a point resting on the arc of the graduated scale, and held by friction at whatever point it may be set. Two adjustable contact pieces, *B* and *C*, are carried by this arm. These contact pieces are capable of adjustment by means of a screw *D*, which is so threaded as to cause the contact pieces *B* and *C* to approach or recede at equal rates and distances from the center line of the arm *A*, upon which they are supported.

The contact pieces are also connected to binding posts, as shown, the latter being used for making outside

FIG. 1

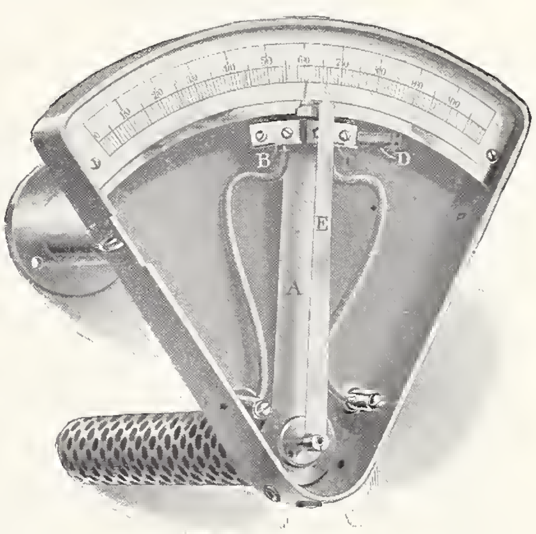


FIG. 2

THERMOMETER-THERMOSTAT MADE BY THE BRISTOL COMPANY, WATERBURY, CONN.

connections. These binding posts are located within the case to avoid any possibility of the wires or connections being disturbed without detection. Three holes with insulating eyelets are provided in the lower portion of the case, as shown, for the insertion of connecting wires. The high and low temperature contact pieces can be placed on a single circuit or on independent ones. The arm *E*, moving over the graduated scale, indicates the changes of temperature. This arm is operated by one of Bristol's recording thermometer tubes placed in the perforated protecting cylinder extending from the back of the case, as shown in the illustration. On the back of the indicating pointer *E*, is a raised portion which makes electric connection with the contact pieces.

The temperature indicating arm *E* acts independently of the arm *A* and the contact pieces *B* and *C*, so that the latter may be adjusted at any desired point, without in any way interfering with the correct indications of the thermometer in case the temperature does not remain, or is not controlled within the limits for which the contact pieces may be set.

The instrument may be readily applied to indicate the temperature of liquids, and set in operation controlling apparatus for the brine in a refrigerating system or tank.

For temperatures above the atmosphere, as that in ovens, kilns, closed spaces, or of liquids in pipes under pressure, a small bulb is located within the closed space or pipe. This bulb is connected with the thermometer-thermostat by a capillary tube filled with alcohol. The temperature at the bulb is communicated to the instrument, the latter being located at any convenient point for observation.

The electric wires connecting with the adjustable thermostatic contacts may be carried to any point where the controlling apparatus is located or where it is desired that an alarm shall be given.

FIG. 1.—NERNST LAMP WITH REFLECTOR

Nernst Lamps for the St. Louis Exposition

AMONG the many applications of electricity to be seen at the St. Louis Exposition, one that will be of interest to artists and lovers of art, as well as electric light men in general, is the application of Nernst lamps on a large scale to the lighting of the Fine Arts Exhibit.

Since the advent of these lamps upon the market three years ago, the steadiness and quality of the light have proven of distinct advantage in all cases where a correct determination of color values is important,—hence their special adaptability to illuminating an exhibit of fine paintings. Owing to the downward distribution of the light, also, a great uniformity of illumination is secured over the wall space usually occupied by an art exhibit, the weaker rays being in the direction of the upper and the nearer portions of the wall, and the stronger rays in the direction of the lower and more distant portions.

Where the exhibits occupy the walls exclusively, the uniformity and intensity of the wall illumination is greatly improved by the use of a specially designed reflector on each lamp, similar to that shown in Fig. 1. This reflector is of light, rigid construction and is fastened to and supported by the lamp.

The reflector also acts as a shield, preventing direct light from entering the eye of the observer.

The preliminary tests made with this reflector under conditions approximating as nearly as practicable the actual art gallery conditions, were attended with very satisfactory results, as evinced by the exclusive acceptance of the Nernst system by the art officials. The plans involve the use of 1541 Nernst lamps of different sizes, making a total of 4780 glower units, with a total consumption of 401,520 watts. The sculpture halls will be lighted by means of large clusters, each consisting of 19 six-glower lamps at 60 feet elevation. In the art gallery section, the three-glower lamp, with the special reflector, will be the standard unit, these being arranged around the four sides of the room 8 feet from the wall, as shown in Fig. 3. The lamps will all be supplied with 25-cycle current from a single-phase 210-volt circuit. A portion of the load on the latter is used for power purposes.

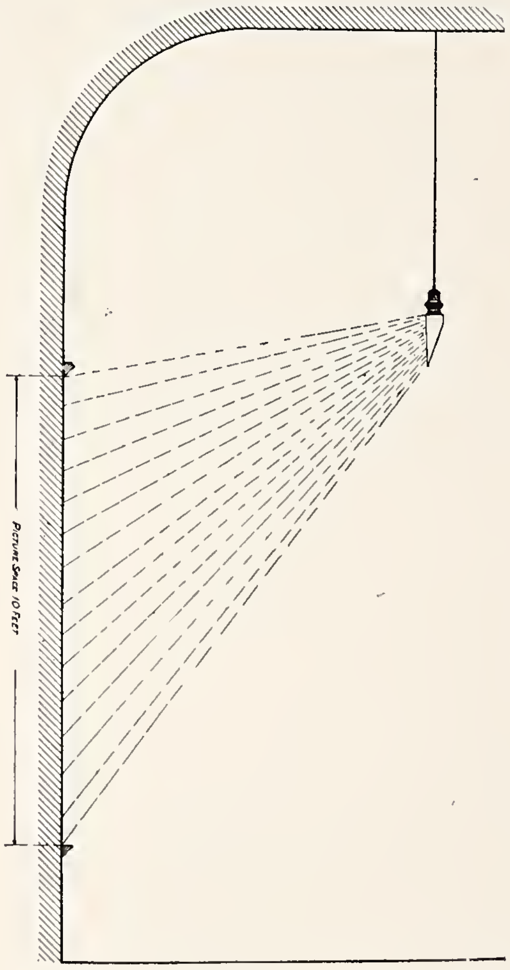


FIG. 2.—ARRANGEMENT OF NERNST LAMP FOR ART GALLERY ILLUMINATION

Inasmuch as this installation, the first of its kind, represents a radical departure from the accepted method of the past for art gallery lighting, the results will no doubt be noted with interest and should furnish some valuable data, both as to the value of the Nernst lamp in this particular field and in its operation on power circuits of 25-cycle frequency.

Third-Rail Protection in England

THE English "Railway Review," the organ of the Amalgamated Society of Railway Servants, when pointing out recently the fact that the electrification of steam railways is adding another danger to railway men, and to some extent to the

general public, urged that the Lancashire & Yorkshire Railway Company should provide some form of protection for the live rail other than the issuance of a mere "note to its employees on the danger of touching the live rail, and instructing them to use their best endeavors to prevent the public from doing so." The "Review" further says that "the Northeastern Railway Company has protected its live rail by the erection of two iron or steel ridges which run parallel with and rise above the rail on each side, so that when a person inadvertently places his foot across the metal it is held away from the live rail by the two ridges which form the careless person's foot into a bridge, thus saving him from a violent and immediate death."

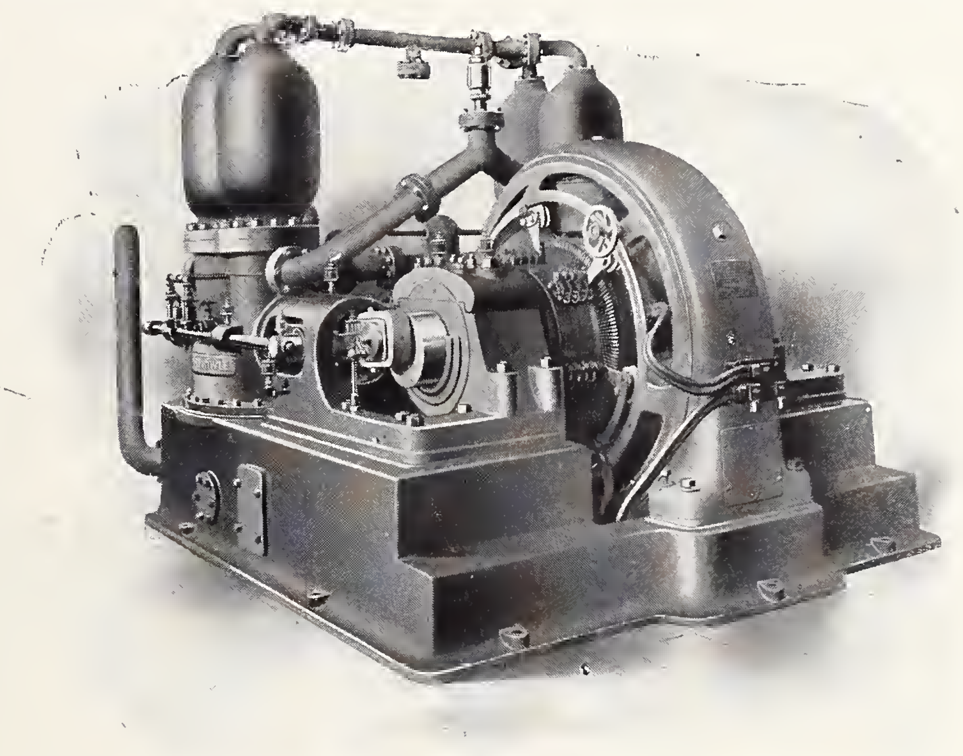
A High-Speed Electric Motor-Driven Pump

THE operation of pumping machinery by electric motors offers, especially in mines, many obvious advantages, such as the centralization of the power plant, elasticity of extension of the system, high efficiency and small first cost and small expense for attendance. Compressed air may be used for the distribution of power to pumps, but it is not usually recommended on account of the low efficiency of the plant as a whole. Small leaks, if many, become serious, and the long line of piping with numerous joints causes frequent delay, trouble and expense. The use of steam for driving pumps at a distance, and especially in mining operations, is decidedly objectionable on account of the loss of condensation, the heat from the engines and pipes, the expensive piping and the numerous joints liable to leak, as well as to give rise to danger from bursting.

Electrically driven pumps, however, have had one drawback. This was the necessity for toothed gearing, belts or other devices to transfer the power from the rapidly revolving motor shaft to the slow-moving crank-shaft of the pump. Such devices added to the weight and size of the pumping unit and required either careful attention or frequent repairs. The use of toothed gearing on pumps in buildings is, moreover, objectionable on account of noise.

In the pump here illustrated, these objectionable features have been eliminated by the simple expedient of connecting the pump plungers to cranks mounted directly upon the shaft of the motor. This pump has a capacity of about 250 gallons per minute against 1000 feet head, when running at a speed of about 300 revolutions. So carefully have the internal parts of the pump been designed, however, that its mechanical efficiency is claimed to be over 93 per cent, approximating closely that of the highest types of large steam pumping engines. The pump is of the duplex type; the cranks at the opposite ends of the motor shaft being set at right angles to each other. The plungers are of the outside packed pattern, and the two plungers of each pump are connected by side rods. The plungers are $3\frac{1}{2}$ inches in diameter and have a stroke of $5\frac{1}{2}$ inches.

The pump and motor are mounted upon a rigid box-girder frame, and the unit is self-contained and occupies a relatively small space. It contains many novel features of construction, and the most careful attention has been given to the design of the internal parts, as well as to the running parts and oiling devices. High speed pumps have been constructed heretofore with mechanically operated valves, but have proved far from satisfactory, and in many cases the entire valve mechanism has been removed with beneficial results. Some designers advocate closing mechanically both inlet and outlet valves, while others favor mechanically opened valves; again, some constructors operate one set of valves mechanically; still others maintain that such complicated mechanisms are useless and lead only to trouble and expense.



A HIGH-SPEED ELECTRICALLY-DRIVEN PUMP MADE BY THE BLAKE & KNOWLES STEAM PUMP WORKS, NEW YORK

This type of pump, which has only lately been introduced, has such advantages as simplicity of construction, small space requirements, cheapness of installation and attendance. The pumps are built by the Blake & Knowles Steam Pump Works, of 114 Liberty street, New York City, in capacities of from 200 to 4000 gallons per minute, and for heads varying from 100 to 2000 feet. One of these pumps, operated by a direct-current motor, will be exhibited in the space of the General Electric Company at the St. Louis Exposition.

Rope versus Electric Power Transmission

TWO papers on rope transmission of power, which were read by Frederick S. Greene before the New England and Southern Cotton Manufacturers' associations, have called forth a great deal of discussion relative to power transmission by the various methods in use. The fact has been quite well established that rope driving is an economical way of transmitting power in textile plants, but the figures presented by Mr. Greene have greatly emphasized the advantages of this method.

Some criticism has been made upon the paper read at the Boston meeting in the interest of electrical apparatus, the point being taken, according to "The Iron Age," that the method of electrical installation used as a basis for comparison was not the most advantageous or latest improved. This criticism was answered by Mr. Greene at the meeting of the American cotton manufacturers at Washington, who there made the statement that he did not claim that the method used for comparison was either the best or the worst way to install electrical transmission, but from many prices

received from nearly all the makers of electrical apparatus he had selected the cheapest. He said that each firm applied to and each engineer questioned on the subject had suggested different arrangements for the motors, some advocating a large number of small motors, while others inclined to a few large ones. He further said that while he was willing to admit that he did not know the best way to install electrical transmission in a cotton mill, so far as he could find out no one else did; certainly no two electrical companies agreed on the subject.

This discussion has led to a definite proposition, which is now publicly offered by the American Manufacturing Company, of New York, who are manufacturers of transmission rope and other cordage. They agree to furnish the necessary rope sheaves, rope and driven head for the main drives of any cotton or woolen mill in the United States, using 500 or more horse-power, which is developed at the mill site, at one-quarter the price for which any responsible company furnishing electrical apparatus will agree to install the generators, motors, motor shafts, switchboard, wiring and other appliances necessary to electrically transmit the same power. Where the power is generated at a distance, if the mill will install one central motor, the company will agree to distribute the power from the motor to the main line shafts with rope drives for one-half the cost of electrical apparatus to distribute the same power. The offer which is thus made is likely to bring out some interesting facts.

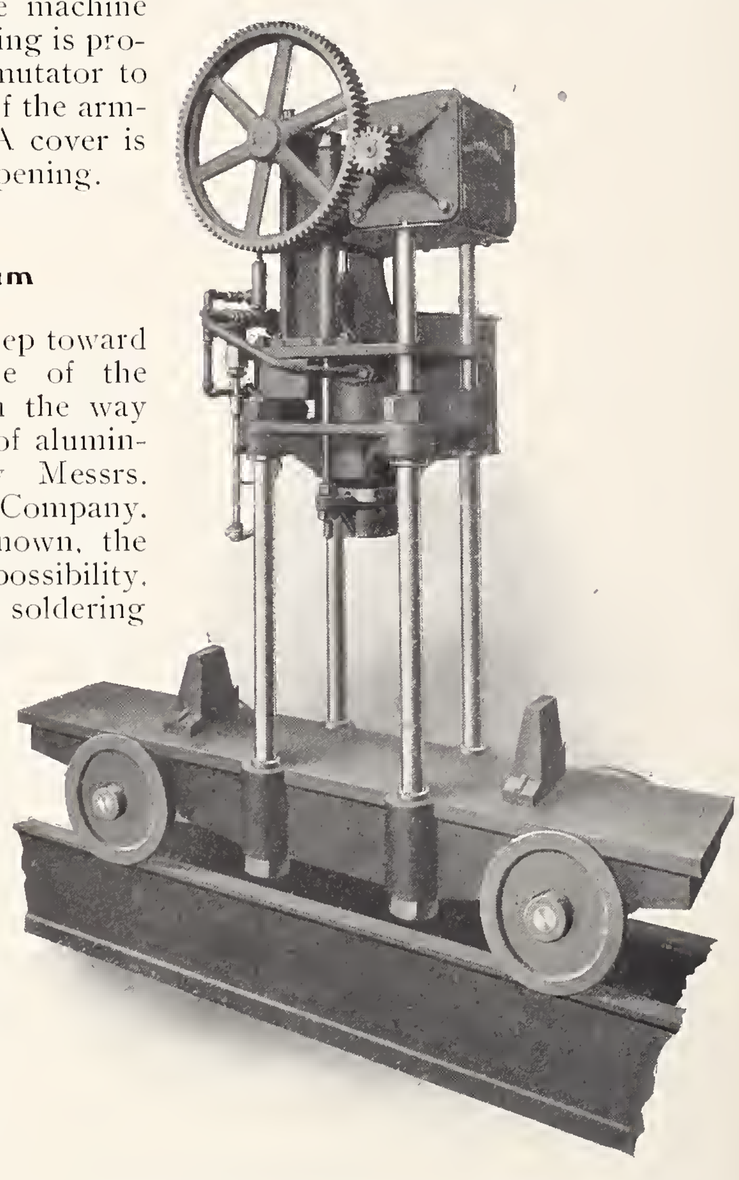
A Motor-Driven Shaft Straightener

A HYDRO-ELECTRICALLY operated shaft-straightening lathe made by the Logemann Bros. Company, of Milwaukee, Wis., the pump motor accessory being supplied by the Northern Electrical Mfg. Co., of Madison, Wis., is shown in the annexed cut.

The shaft straightener is essentially a hydraulic press mounted on a carriage traveling over the bed of the lathe, as shown. The press is operated by a pump of the triplex type, geared to a motor of the box type, shown at the top of the machine. The motor is in constant operation while the lathe is in use, the pump pressure being regulated by a by-pass valve, placed in the discharge between the pump and the water tank. By this method a very delicate adjustment of pressure can be obtained.

The head stock, not shown in the illustration, has a variable speed attachment, adapted for either motor or belt drive. The tail stock is provided with a tool rest, for use in facing off couplings, etc., on the shaft. Wedge blocks, placed on the planed bed of the carriage, are adjustable to various diameters of shaft. The carriage is fitted with roller bearings and may be easily moved along the bed in order to bring the press plunger over the spot in the shaft to be straightened.

The motor is encased in a steel, dust-proof box, the body of which is formed by the field frame. Bosses are cast on the ends, sides and bottom of the frame to be drilled and tapped for attaching the motor to the machine driven. A convenient opening is provided over the entire commutator to permit of ready inspection of the armature and brush-holders. A cover is accurately fitted over this opening.



A MOTOR-DRIVEN SHAFT STRAIGHTENER, MADE BY THE LOGEMANN BROTHERS COMPANY, MILWAUKEE, WIS. THE MOTOR IS SUPPLIED BY THE NORTHERN ELECTRICAL MFG. COMPANY, MADISON, WIS.

Welding Aluminium

A CONSIDERABLE step toward the removal of one of the greatest obstacles in the way of the more extended use of aluminium has been taken by Messrs. Sherard, Cowper-Coles & Company, of London. As is well known, the difficulty, if not the impossibility, of making a satisfactory soldering joint between two pieces of that metal has limited its application in no small degree. The difficulty of soldering aluminium is due to the formation of an imperceptible, but extremely tenacious, film of oxide on the surface of the metal, and it is to the presence of this film that the possibility of the process devised by Mr. Cowper-Coles is due.

The apparatus used to illustrate the new method is described in "Engineering" as consisting of a frame carrying a pair of movable clamps, each of which gripped one of the aluminium rods to be welded. The rods were held horizontally, the ends butting together in front of the flame from a gas blow-pipe. No special cleaning of the surfaces was necessary nor was a flux of any kind applied. As soon as the ends appeared to soften by the heat, they were lightly pressed together by means of a conveniently placed lever connected to the clamps, and at the same instant a shield descended in front of the flame to prevent any further heating. The descent of the shield caused a douche of cold water to be applied to the weld and the operation was complete.

The principle underlying the process is as follows:—The heat of the blow-pipe flame causes the formation of an oxide skin on the aluminium as above mentioned, which is strong enough to act as a bag, the interior being full of molten metal. When the ends of both bars are in this condition and are pressed together, the skin bursts at the point of contact, the molten metal unites, and is instantly solidified by the water douche. The existence of the "bag" of fluid metal was clearly shown by a further experiment, in which an aluminium rod was clamped at each end, the center portion being subjected to the action of the blow-pipe flame. When the metal liquefied, the molten portion sagged down, contained in a flexible tube of oxide, which, on being pierced, allowed the fluid metal inside to run out.

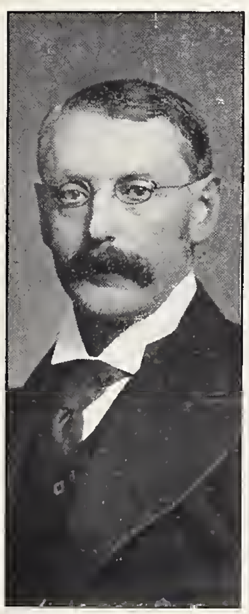
It is understood that Messrs. Sherard, Cowper-Coles & Co. are perfecting a method of uniting tubes by this process, the formation of a ridge on the interior being prevented by the use of a mandrel inside the tube.

Galvanizing by the Electrolytic Process

According to the London "Electrical Engineer," the electrolytic process of galvanizing has been much developed in recent years, and is now used even for heavy pieces of machinery, such as parts of centrifugals for sugar factories, which cannot be galvanized by immersion in melted zinc without becoming distorted. It has been found that articles galvanized by electrolysis can be punched, riveted, and otherwise worked without the zinc peeling off. Press-rolls also are now treated by this process. The old method had several disadvantages, of which the worst, perhaps, were the unequal thickness of the zinc coating and the lumps formed by the dripping of the melted zinc, both of which necessitated the roller being turned in the lathe in order to obtain the proper surface. The electrolytic deposit of zinc, on the contrary, is perfectly uniform, and no turning is required, so that the roll can be used just as it comes from the zinc bath; besides which the rolls do not warp, as was frequently the case with the old process, the electrolytic precipitation of the zinc being carried out cold.

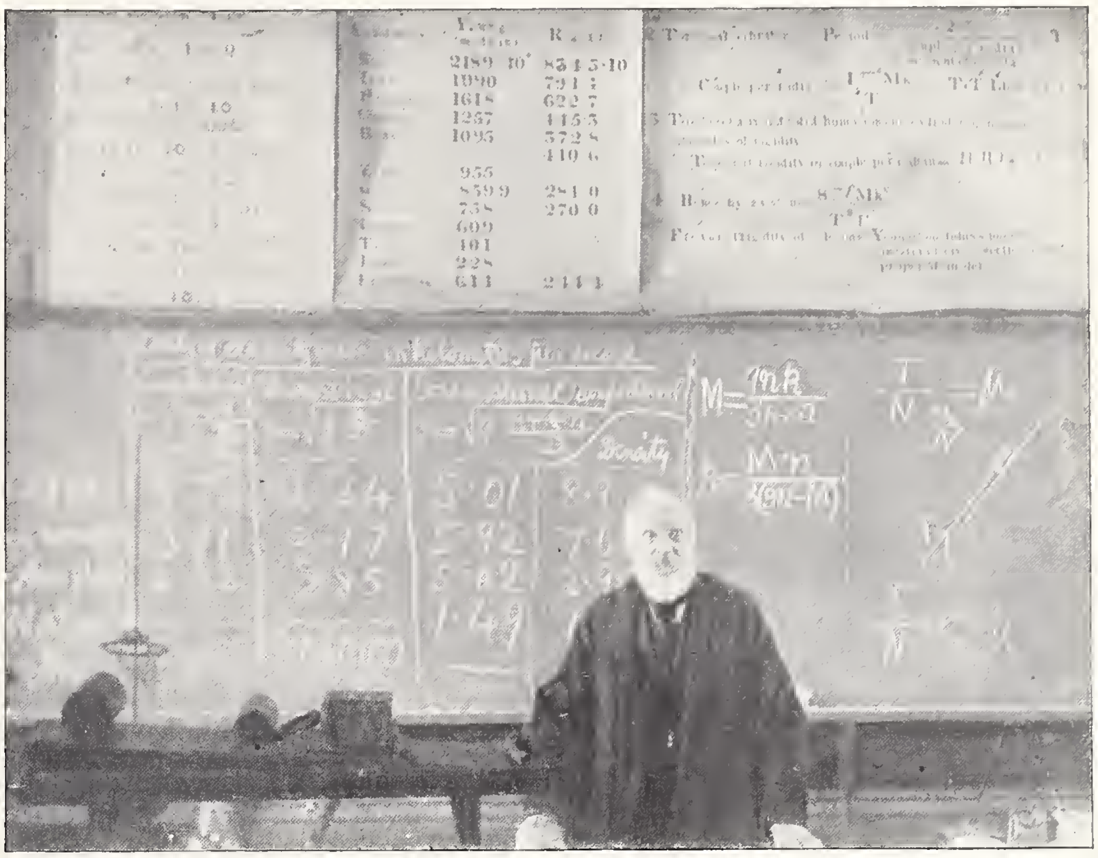
Personal

With the remarkable development in steam turbine engineering during the past few years, which has given special prominence in the United States to the Parsons, the De Laval and the Curtis designs, and in Europe to the Riedler - Stumpf, the Rateau and the Zoelly turbines, it is not uninteresting to recall that the Hon. Charles A. Parsons, a son of Lord Rosse of telescope fame, introduced his first practicable turbine in 1884. It was rated at 10 H. P., and while not an economical machine, successfully demonstrated the principle. It ran at a speed of 18,000 revolutions per minute, and used 35 pounds of steam per horse-power per hour. Four years later Mr. Parsons brought out an improved turbine of 50 H.P., making 7000 turns per minute, and soon afterward a 200-H.P. machine running at 4000 turns. The famous little turbine-driven steamer "Turbina," which ran at a speed of about $39\frac{1}{2}$ miles an hour, startled the engineering world in 1897.



C. A. PARSONS

According to the "Manchester Guardian," Lord Kelvin's election to the lord chancellorship of Glasgow University has loosened the flood of anecdotes which have gathered round his great name. Most Kelvin stories which obtain in Glasgow are founded upon the occasional inability of the great man who lisped in logarithms to bring his mind to a childish sum. The famous one tells how on his blackboard he once made two and two five, and, hearing the chuckles of his delighted class, altered it hastily to three. He was, however, once heard to say, in his characteristic slow way, with his beautiful use of the soft Irish r, "Seven times nine, Mr. Mac-far-lane, are a hundred and what? [Pause.] But, no; seven times nine cannot be a hundred and anything, Mr. Mac-far-lane, for the square of a hundred is ten." It is also told of him that, walking one day with a friend in Largs, he noticed that it had begun to rain. He questioned his friend closely as to where his coat and his umbrella were, and having satisfied himself that his friend had not these articles with him, he said:—"Well, in that case, doctor, we will walk back beneath this belt of trees, for the rain will not per-colate the leaves, doctor, for twenty minutes.



LORD KELVIN ADDRESSING ONE OF HIS CLASSES

Mr. C. C. Tyler has resigned his position as superintendent of the works of the Westinghouse Electric & Manufacturing Company, at East Pittsburg, Pa., and has been appointed general superintendent of all the works of the Allis-Chalmers-Bullock interests in the United States. Mr. Tyler will enter upon his new duties on June 15, and will make his headquarters at Milwaukee. His record in the practical management of great machine shops is one of the best in the country, and it has long been under the appreciative observation of men who understand the value of such ability. Before Mr. Tyler went to Pennsylvania he had made an excellent reputation, and at Pittsburg, where he has been for half a dozen years, he enhanced this by the results he achieved in increasing the efficiency of the Westinghouse electric works. In the equipment of manufactories, in the design and construction of machine tools, in the handling of machinery and material, in processes of manufacture, and, in fact, in all that pertains to the economy of machine shop administration, Mr. Tyler is recognized as an expert who has no superior in this country. In entering upon his larger field of duty he is sure to carry with him the congratulations of the engineering profession.

Paul M. Mowrey, who for the last three years has been connected with the Merchants' Trust Company, of New York, as adviser on industrial investments, has assumed the office of vice-president of the Engineering

Company of America. Mr. Mowrey has been prominently identified with the engineering and contracting business since 1888, when he became connected with the Edison Illuminating Company. Among his numerous successful enterprises was the purchase and consolidation of the street railway and power companies of Richmond, Va., which were later turned over to Frank Jay Gould.

W. D. Dickinson, superintendent of the Boston & Great Falls Electric Light & Power Company, the Great Falls Street & Power Company, and the Boston & Great Falls Land & Power Company, for the past thirteen years, has severed his connection with these companies. It is reported that Mr. Dickinson will leave Great Falls, Mont., and make his home in California.

J. C. McQuiston has been appointed superintendent of the Westinghouse Company's publishing department at Pittsburg, having charge of matters

J. C. MCQUISTON

relating to the publicity of the products of the various Westinghouse interests in the United States and Canada.

Mr. H. V. Croll, who has been in charge of the Salt Lake City, Utah, office of the Allis-Chalmers Company for several years, and who was before that the representative of the E. P. Allis Company at Spokane, Wash., has been appointed to the charge of the Allis-Chalmers office in San Francisco, as the successor of Mr. George Ames, who has resigned. Mr. Croll's San Francisco office is 623 Hayward Building.

James W. Lyons, who has been for many years associated with the Allis-Chalmers Co., in the capacity of engine salesman, has been appointed manager of the newly created power

JAMES W. LYONS

department of the Allis-Chalmers Co., with headquarters in Chicago, the appointment taking effect Monday, May 16, 1904. This newly created power department will control the sale of reciprocating steam engines, steam turbines (entire units, including turbo-generators), condensers, gas engines, pumping engines, blowing engines, hoisting engines and air compressors. Mr. Lyons' well-deserved promotion will gratify his many business friends throughout the country, for he is very well known, and it is an evidence that the management is determined to preserve the best traditions of the Allis-Chalmers Company.

Mr. C. O. Baker, president of Baker & Company, Incorporated, of Newark, N. J., and New York City, N. Y., the well-known refiners and artisans in platinum, gold and silver, sailed recently for his annual trip abroad.

Gas engines for central station service formed the subject of an interesting paper recently read before the New York Electrical Society by Ralph D. Mershon.

R. D. MERSHON

Arthur Warren, chief of the Department of Publicity of the Allis-Chalmers Company, of Chicago, has contributed to the June number of the "American Monthly Review of Reviews," an interesting article on "The Turbine; A new Era of Steam," telling of the changes which the steam turbine is making in engineering both afloat and ashore.

John B. Allan and Arthur West, both connected until very recently with the Allis-Chalmers Company, have joined the forces of the Westinghouse Machine Company, of Pittsburg. Mr. Allan will be the Western manager of the company, with headquarters at Chicago, while Mr. West will assume the post of chief engineer of the company at East Pittsburg.

Having very recently perfected his new differential water wheel governor, Mark A. Replogle, of Akron, Ohio, has been retained by the Replogle Governor Works as chief engineer, and the manufacture and sale of this new machine will begin in earnest.

Bion J. Arnold has been appointed consulting electrical and mechanical engineer for the Illinois Tunnel Co., of Chicago, which will install a narrow-gauge electric railway in the tunnels under Chicago streets. About 40 miles of tunnels have already been completed. It is proposed to form a general freight collecting and distributing business, thus obviating a large portion of the teaming that now greatly congests the streets above. The necessary power statons, type of equipment, signalling and switching system, and method of conducting this transportation are all interesting factors in the problem.

B. J. ARNOLD

Lewis Buckley Stillwell

Electrical Director of the Interborough Rapid Transit Company, New York

WITH the near completion of the construction work of the Interborough Rapid Transit Company, by which the city of New York will have one of the most perfectly designed passenger traffic systems in the world, interest will be centered largely in the men whose labors have helped in the carrying out of that enterprise, and among them Lewis Buckley Stillwell, the electrical director of the company, occupies a prominent place.

Photo by Ames, New York

LEWIS BUCKLEY STILLWELL,

ELECTRICAL DIRECTOR OF THE INTERBOROUGH RAPID TRANSIT COMPANY, NEW YORK

Indeed, Mr. Stillwell ranks conspicuously in engineering circles generally as a man of unusual achievements, still young and yet identified since early in the nineties with the successful working out of some of the world's most important practical engineering problems,—the generation and transmission of Niagara power, for example, the electrification of New York's elevated railway system, and the electric equipment also of New York's rapid transit subway.

Mr. Stillwell was born in Scranton, Pa., March 12, 1863. Although a Pennsylvanian by birth, he is a descendant of an old New York family, prominent in the Colonial history of the province, this name appearing more frequently than any other save one in the lists of members of the Colonial Assembly of New York from 1691 to the time of the Revolution. His father, born in 1824, was a soldier in the Civil War, serving as captain in the 132d Pennsylvania Volunteers, and receiving a severe wound at the assault on Marye's Heights at the battle of Fredericksburg. Subsequent to the war he acted for many years as general superintendent of anthracite coal breakers of the Pennsylvania Coal Company.

On his mother's side, he is of German stock, his mother being a granddaughter of General Peter Kichlein (1722-1789), member of the Committee of Safety of the Colonies (1774-1776), and greatly distinguished at the battle of Long Island, where he commanded a regiment of Pennsylvania riflemen, which, at the cost of nearly half its numbers, held its position until the American line being broken elsewhere, practically the entire remnant of the regiment, including its colonel, was captured.

He was graduated at the Scranton High School, matriculated at Wesleyan University, and after two years' work there took up the study of electrical engineering at Lehigh University, where he completed the electrical course in 1885, taking post-graduate work at Lehigh in mechanical engineering, 1885-86. In October, 1886, he accepted the position of assistant electrician of the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., where he was associated with O. B. Shallenberger, William Stanley and Nikola Tesla, particularly in the commercial development of the alternating-current systems of lighting and power distribution.

In April, 1890, he was promoted to chief electrical engineer, and in April, 1895, to chief electrical engineer and assistant manager. In March, 1897, he resigned and became electrical director of the Cataract Construction Company and Niagara Falls Power Company, at Niagara Falls, N. Y., having while with the Westinghouse Company directed the preparation of the plans for the electrical utilization of Niagara which were finally adopted by the Cataract Construction Company.

At Niagara he became responsible not only for the work of electrical construction in connection with the extensions of the installation, but also of the operation of the plant as completed. During his residence at Niagara many of the problems met with in electrically transmitting and distributing power at high potential and in great amount for industrial purposes, as well as for lighting and for the operation of street railways, were encountered for the first time in commercial service, and to their solution and to the organization of the operating force and methods of the company he devoted the greater part of his time for the ensuing three years. While thus engaged, he made an exhaustive study of the subject of charges for power, as fixed by cost of production and by cost of power developed by competing steam plants, and prepared a schedule of charges which was adopted by the Niagara Falls Power Company and has since served as the basis for its contracts throughout the territory supplied from its plants. He also prepared a system of classification of accounts for the operating department which has since been used by the company.

While at Niagara, he acted as consulting engineer for various enterprises other than the Niagara development, and in March, 1899, accepted the position of consulting electrical engineer to the Manhattan Railway Company, of New York City, taking charge of the design and installation of the complete electrical equipment of the elevated lines. In September, 1900, the first power plant at Niagara being completed and in successful operation, he resigned his position with the Niagara companies to give his entire time to the Manhattan Railway Company and to practice as consulting engineer in the city of New York. He subsequently received from the president of the Cataract Construction Company the Niagara medal, designed by MacMonnies and engraved by Paulin Tasset.

In November, 1900, he became electrical director of the Rapid Transit Subway Construction Company, now the Interborough Rapid Transit Company of New York, in addition to his other official and professional duties.

Mr. Stillwell has patented a number of important inventions having to do with the practical application and use of electricity in power transmission and railway practice. He is a member of the American Philosophical Society; the American Society of Civil Engineers; the American Institute of Electrical Engineers; the British Institution of Electrical Engineers, and of many other scientific and engineering societies. His scientific papers, presented before technical societies and in some of the leading technical periodicals, include the following:—"The Electrical Transmission of Power from Niagara Falls"; "Frequency in Alternating Current Plants for Lighting and Power"; "The Relation of Size and Efficiency in Transformers"; "Possibilities of Electrical Transmission and Distribution of Power in Pittsburg"; "Electrical Equipment of the Manhattan Railway Company"; and "Electric Power Generation at Niagara," this last having been prepared specially for the Niagara Power Number of "Cassier's Magazine," published in 1895.

Gutta Percha in the Philippines

The Bureau of Government Laboratories at Manila has forwarded to the War Department at Washington a report upon the gutta percha and rubber situation in the Philippine Islands. The report deals briefly with the commercial history of gutta percha and its discovery, and the rapid depletion of the supply in the East India Islands. The last source of gutta percha developed is that in the Philippine Islands, but here the regions which produce this material for the market are confined to the islands of Mindanao and Tawi-Tawi. The method of harvesting used at present by the natives consists in cutting down the large trees, ringing the trunk, lopping off the larger branches and then catching the milk as it flows out. This is very wasteful, as but a small part of the milk is secured. Fortunately, however, this process pays only with large trees, so that the smaller ones are not destroyed. This method of harvesting has been prohibited, and rules provided for tapping the trees, but these have never been enforced. At the present time, the gutta percha trees have disappeared from the coast regions and are along the large rivers.

One of the features of "Dreamland," the new amusement resort at Coney Island, New York, is a tower 375 feet high lighted with 100,000 electric lights. The total number of lights on the buildings, the tower and the avenues runs up to a million.

Influence of Electricity on the Strength of Metals

In a paper on "The Physical Properties of Current-Bearing Matter," recently presented before the physical section of the Franklin Institute, Dr. Paul R. Heyl stated that Peltier sent currents through wires of copper and iron for from 4 to 19¼ days, afterwards breaking them while no current was passing. It appeared as if copper was weakened by this treatment and iron strengthened. There are several objections to be urged in this connection, chiefly the long continued thermal effect, and the fact that pieces of wire cut from the same spool may vary several per cent. in tensile strength. The latter difficulty can be eliminated only by a large number of systematic observations.

Wertheim broke wires while the current was passing, and found that gold was apparently weakened about 40 per cent. He seems to have broken one such wire with the current and one without it. In a few experiments on iron and steel he found changes sometimes one way and sometimes the other, of the order of 2 to 10 per cent. His treatment of the subject is not sufficiently elaborate, and he says himself that he is unable to distinguish between the sought effect and the acompanying thermal effect.

The Development of Water Powers

Speaking of the development of water-powers in his presidential address a short time ago before the Institution of Civil Engineers, Mr. John Clarke Hawkshaw gave a brief, but interesting, survey of some of the more important accomplishments in this branch of engineering in different parts of the world and of the possibilities yet to be realized.

The great difficulty in the way of utilizing falls of water for industrial purposes is the variation in the supply of water, which, in all water courses, depends upon the seasons. In some cases, as Mr. Hawkshaw remarked, the supply falls off in winter when the sources are frozen, and is abundant in summer when glaciers and snow melt. In others the reverse is the case, and the falling off is during the summer droughts. Even Niagara, notwithstanding the regulating effect of the Great Lakes, is subject to considerable variation. But where, as Niagara, the available power is so much in excess of requirements, this variation is of little moment if we consider only the supply of water for power; and yet an artificial regulation of the lakes is under consideration, with a view to prevent too great a variation in the level of the surface owing to the discharge through canals, for power and other purposes. In smaller rivers it is necessary to consider the minimum flow, and if that falls very low, or is subject to much variation from year to year, the uncertainty may make the source of power of little value.

The only remedy against this variation is to regulate the flow of water in the river by building dams and storing the flood-water at suitable places. In a settled country this will generally be a matter of great difficulty, and often of prohibitive cost, owing to the interference with vested interests which any variation of the accustomed levels of the water will bring about. The cost is reduced to a minimum when lakes can be used for storage reservoirs.

At Foyers, the one example of water-power used for industrial purposes on a considerable scale in Great Britain, sufficient water could be obtained only by lake storage. In Ireland, the Shannon is a river well adapted for providing water-power. It has a rapid fall near the sea, and large lakes conveniently placed for storage reservoirs; but fisheries, navigation and the vested rights of riparian owners have, so far, barred the way to the full use of the large power available there.

In countries where the land is uncultivated and of little value, as in parts of South Africa, and where the rivers are dry or of small volume at certain seasons of the year, it will often be possible to form large reservoirs in the river valley itself, at a comparatively small cost; but, as a rule, this will exceed the cost of storing water in existing lakes.

In Norway the greatest facilities exist for regulating the rivers, and thereby obtaining a large measure of the power to be derived from the water flowing into them. Lakes, many of large size, may be numbered by thousands. Many of these have already been regulated, some for navigation purposes and some for timber-floating and some are now being regulated for water-power. On Lake Mjösen storage has been provided for 840,000,000 cubic meters, at a cost of £14,400. It is estimated that 263,000 H. P. could be supplied by the larger rivers of Norway south of Trondhjem without regulation; by regulation the power would probably be quadrupled.

At one of the falls on the Glommen, where there is 45,000 H. P. available, a power house has been erected from which the power will be transmitted to Christiania. Germany, Austria and Switzerland have made larger use of water-power for industrial purposes, and in some cases for working railways. France uses water-power to the extent of 500,000 H. P. already. Italy is making use of her waterfalls, transmitting power to a distance of 62 miles on Lake Como for railway and other purposes.

It is in the United States, however, that most progress is being made in the electrical transmission of water-power. Forty-three companies, having a total capacity of 177,300 H. P., transmitted power over a line distance of 1594 miles, on an average 36 miles, with a voltage which ranges from 10,000 to 60,000 volts. The maximum distance over which power is transmitted is from Colgate to San Francisco, 220 miles, with a loss of 25 per cent. Waterfalls are made use of under the most varied conditions as regards volume and fall. At Niagara the body of water is large, and the fall is between 150 and 200 feet; at Sault Ste. Marie, between Lakes Superior and Huron, the body of water is also large, but the fall is small, namely, 24 feet; at Colgate the body of water is small, but the fall is 1500 feet.

Russia in Europe has not available water-power at all in proportion to its area. An Imperial Commission recently decided that the water-power on the navigable rivers belongs to the government, and its utilization will depend on how far they deal with it in a liberal spirit. The hot, dry summers and cold winters are not favorable to water-power; and it is believed in Russia that the increasing destruction of forests is prejudicially affecting the rivers, which have too much water in spring and too little in summer.

Several imortant projects are, however, under consideration. One is to develop 100,000 H. P. on the river Mista to work the St. Petersburg & Moscow railway. Another is on the Volkhov River, which connects the Ilmen and Ladoga lakes. At the falls of the river Narova, at Narva, it is estimated that 40,000 H. P. can be obtained, of which 15,000 H. P. is already used. In Finland there are the Great and Little Imatra Falls, also Prince Menchikoff's Rapids, near Kotka, with 40,000 H. P., of which 15,000 H. P. is already utilized.

In South America, where coal is wanting, the rivers which flow down the western slopes of the Andes will form a fruitful source of power. In Argentina a beginning has already been made at Cordova. Many of the rivers from the Andes are now absorbed in the arid deserts of the western pampas, and their regulation will

serve the double purpose of irrigation and power. Brazil has one grand fall, that of Paulo Alfonso, 147 miles from the sea on the Rio San Francisco, which is navigable to the fall. By some who have seen both, this fall is regarded as a finer sight than Niagara.

Africa, with its four great rivers and notable waterfalls, has a vast amount of water-power in store for the future. Notwithstanding the requirements for irrigation, some water should be available for power at Assouan, on the Nile. Above the first cataract are six more, and further south are the Murchison Falls, where the Nile descends 700 feet in 10 to 15 miles. On the Zambesi there is the Victoria Fall, with a height more than two and a half times that of Niagara.

At Stanley Pool, on the Congo, Stanley estimates the discharge when the river is lowest at 1,436,850 cubic feet per second, more than four times the maximum discharge at Niagara. In Southern India a beginning has been made. Electric power is supplied to the Kolar gold fields from the Cauvery Falls, distant 90 miles; and it is estimated that 60,000 H. P. can be obtained from the Periyar reservoir, which was made for irrigation purposes.

There are other sources available for water-power in northern India, some of which have already been considered with a view to their utilization. In course of time these great waterfalls of the world will all become centers of industry and manufacture.

Electric Action in Plants and Animals

SOME of the results of the latest investigations of electrical phenomena in plants and animals are given in an article by Dr. W. Biedermann, in the "Ergebnisse der Physiologie" (Wiesbaden).

According to extracts from this, printed in the "American Monthly Review of Reviews," there is nowhere else in organic nature an example of the direct generation of mechanical and electrical energy, on a large scale, of corresponding adaptation of structure and change of function, similar to that found in the so-called electric fishes, which have the power of discharging electricity at will, as a means of defense.

A number of fishes have this power to a certain degree, but the electric organ is most perfectly developed in the South American eel (Gymnotus), in which there is a pair of electric organs lying on the ventral side of the tail; in the electric sheath-fish (Malapterurus), in which the electric battery ensheaths the body; and in the fish known as the "torpedo," which has electric organs on each side of the head.

The organs consist of columns of living tissue that originate as muscle, but lose all resemblance to it in the course of development and take the form of thin plates, a fraction of a millimeter thick, placed one above another. The organ has a very large nerve that sends a branch to each plate, and this branch sub-divides inside the electric plate into fine threads forming a delicate network connected with innumerable microscopic electric rods. The active electro-motor principle is supposed to lie in this delicate terminal network, with its electric rods, and the degree of electric power is directly correlated with the degree of development of this structure. It is a noteworthy fact that the blood supply of the electric organ is very meager as compared with the blood supply of the muscles. In the ray fishes the blood vessels never penetrate the plates that compose the organ, but lie between them.

Observations of the action of the electric current were made by means of a telephone placed in connection with the fish and provided with a device attached to the vibrating disk, by means of which any electrical stimulus conveyed to it would be registered by a line drawn on paper. It was found that often there is an electric discharge from the fish while swimming, without any defensive purpose. On account of the manner of swimming, the positive pole of the apparatus was sometimes stimulated, and sometimes the negative pole, and it was found that the quality of the sounds produced through the telephone varied according to the pole stimulated, and may be either weak and dull or sharp and crackling. The electric organs on both sides of the body always discharge simultaneously, like one organ. There is no voluntary variation in the strength of the discharge, but the shock may be made more intense by the cumulative effect of more rapid discharge of the electric organ. A single stimulation of the organ in the electric sheath-fish will produce a whole series of discharges a fraction of a second apart.

The writer distinguishes weak and strong electric fishes. In the former, the organ lies deeper in the tissues of the body, and lacks the finer development of nervous structure found in the latter.

There are certain noteworthy observations on manifestations of electricity in plants which promise to be of great interest from the theoretical point of view. There are probably always electro-motor activities in the different parts of plants, which, it is reasonable to assume, are due to chemical differences in the different layers of cells, and they have been observed, not only as responses to mechanical stimulation, but as accompanying manifestations in the assimilation of carbon dioxide in the regular process of plant nutrition.

Certain plants, among them iris, nicotine, begonia and nasturtium, are more favorable than others for these experiments. If one of them be placed in connection with a galvanometer by means of electrodes attached to leaves on different sides, and one side of the plant be exposed to sunlight while the other side is kept shaded, then within from three to ten seconds after exposure to sunlight there will be a flow of electricity from the lighted to the shaded parts amounting to 0.005 to 0.02 volt. This continues for about five minutes, when the magnet begins to swing back and shows an opposite current of considerable magnitude. The manifestations are similar to those of tetanized nerve.

The electric current of green leaves is least in diffused daylight, greater in refracted light, and most in direct sunlight, and it is further affected by the temperature, 20 degrees C. being the optimum for iris. Cooking the leaves destroys their electric activity, and the electric manifestations are not found in plants that do not have geen leaves. This was considered as proof that the generation of electricity accompanies the assimilation of carbon dioxide.

Minerals containing radium are said to have been discovered in the Province of Quebec. The ore from which radium and oxide of uranium have been extracted was taken from a white mica mine about 18 miles back of Murray Bay, in Charlevoix County. White mica deposits exist at several points in Quebec and eastern Ontario, and these, according to report, will be developed next summer by an electric company, which hitherto has imported its mica supplies from India.

Trade News

The Westinghouse Company have received orders for the equipment of two long interurban roads on their single-phase system of electric traction. One of these is the Fort Wayne, Decatur & Springfield Railroad, extending between Fort Wayne and Springfield, a distance of 110 miles, and the other is a high-speed line, 53 miles long, between Indianapolis and Connelsville. The high-

tension feeders are to be worked at 16,500 volts, and the trolley line at 3300 volts, there being transformer substations at about every 10 miles. This tension will be further reduced by static transformers carried on the cars before the current reaches the motors. On the Indianapolis line the cars will run with direct-current when inside Indianapolis city limits.

The Walworth Mfg. Co., of Boston, Mass., announce that they have revised the list on Stillson wrench parts and that this revised list can be had upon application in advance of circulars that will be sent to the trade at as early a date as possible.

The Shepherd Engineering Company, of Franklin, Pa., builders of Shepherd steam engines, has recently opened a branch office in the Witherspoon Building, Philadelphia, with Edward D. Sidman in charge.

The Arnold Electric Power Station Company, of Chicago, has been retained by the Detroit, Flint & Saginaw Railway, of Michigan, to design its power house, and also the electric distribution system for the proposed trolley line between Saginaw and Flint.

The Canadian business of the Allis-Chalmers Company, which recently acquired the Bullock Electric Manufacturing Company, of Cincinnati, will hereafter be conducted by a new organization bearing the name Allis-Chalmers-Bullock, Ltd. The works and principal offices of this new company are in Montreal.

The Carborundum Company, of Niagara Falls, N. Y., recently shipped two freight cars loaded with products to be displayed at the St. Louis Exposition. One of the principal features will be a great pyramid of carborumdum crystals, 7 feet high and 6 feet in diameter at the base. The crystals are of the most beautiful shapes and colors, and will produce a dazzling effect when properly lighted. The balance of the exhibit will be made up of carborundum wheels, sharpening stones and other products; also samples of different work that has been made possible by the use of carborundum. The display will be in charge of William H. Arison, who had charge of the carborundum exhibit at Buffalo, and E. W. Taylor, who was in charge of the Charleston, S. C., display.

The Bullock Electric Manufacturing Company have removed their New York offices to the Empire Building, No. 71 Broadway.

The Parkersburg, Marietta & Interurban Railway Company is extending its present power station at Parkersburg, W. Va., with Westinghouse-Parsons steam turbines. A 400 K.W. unit will be installed for the present, which will operate on 150 lbs. steam and 28″ vacuum. Steam will be furnished by water-tube boilers without superheater. The generator will furnish 2-phase, 60-cycle current at 2200 volts to a single-phase distribution system supplying current for local lighting. The turbine unit will operate in parallel with the present equipment of the plant, which consists of Westinghouse compound engine generating outfits of the belted type. Westinghouse-Parsons steam turbines also are to be installed in the new power station of the Union Metallic Cartridge Company at Bridgeport, Conn. The initial installation will consist of two turbo-generating units, each of 500 K.W. capacity. The two units will operate in parallel, and will furnish 440-volt, 3-phase current at 7200 alternations per minute for general power and lighting purposes in the various shops located within three or four blocks of the power station. The turbines will operate under 150 lbs. steam, 28″ vacuum, and possibly superheat. The installation is in charge of Mr. Samuel H. Green, consulting engineer, Holyoke, Mass.

The Chicago firm of Becker Bros., composed of O. E. and C. J. Becker, announce to their patrons and friends their removal to their new address, 68 West Washington street. A constantly growing business, both in the Perfection carbon brush and in their motor repair work, necessitated better and larger facilities, and they feel that in their new location they have ample room to care for a larger volume of business. The new building is of brick, 30 x 75, three stories and basement for storage. The first floor is devoted to the office and show room, second floor to repair work and third floor to the brush manufacture and store room for supplies.

The Standard Underground Cable Company, of Pittsburg, in conjunction with the McRoy Clay Works, have a joint exhibit at the St. Louis Exposition immediately adjoining the northwest entrance of the Electricity Building. It shows a cross-section of an actual conduit, consisting of seventy-two ducts, with a manhole at either end, one manhole being complete with a cover, the other being open. A trench, 7 feet deep and 5 feet wide, extends the entire length of this conduit, method of laying conduits, including the wrapping, concrete base and top, enabling close inspection of the and the general construction of the manholes, showing hangers, pipes to poles, etc. At one end in the manhole is shown a capstan rigged up for drawing in cables and connected to a cable which is mounted on a reel at the other manhole, the cable being drawn through the ducts, and part of the ducts being split so as to show the method of fastening cables to rope, etc. From the manholes, cables go to distributing poles, showing the method of distribution to aerial cables for telephone, electric light and street railway work, with various terminals used to protect the ends of the cable in such work. The McRoy Clay Works show piles of clay as it is dug from the ground and the various processes through which the material goes to produce the finished duct. The Standard Underground Cable Company shows samples in handsome cases of all the various cables and appliances made by them. An examination of this system will show, in very complete detail, the method of installing conduits and drawing cables into completed conduits.

The Bristol Company, of Waterbury, Conn., is exhibiting a complete line of recording instruments for pressure, temperature, and electrical measurements, in the Electricity Building at the St. Louis Exposition. The company has also on view specimens of the Bristol steel belt lacing.

New Catalogues

Power presses are the subject of a new catalogue by the E. W. Bliss Company, of Brooklyn, N. Y. In addition to explaining the distinguishing features of this line of its product the Bliss Company also announces that it is considering the manufacture of automobiles.

The draughtsman, engineer or surveyor will find a very complete list of instruments in the catalogue of the Eugene Dietzger Company, Chicago.

An electric coal mining plant is the subject of a pamphlet issued by the Jeffrey Manufacturing Company, Columbus, Ohio. Two sizes of electric coal mining machine plants are briefly described, giving the approximate cost of equipment, together with estimates of savings effected. The same company has also prepared a bulletin dealing with storage battery industrial locomotives.

Wire rope and fittings are shown in a catalogue recently sent out by the

American Steel & Wire Company, Worcester, Mass. Directions for splicing wire rope are given, together with a table showing the proper relation between the rope and wheels used in transmitting power by wire rope, and approximately the amount of power transmitted.

Magnetic chucks and surface grinders are described in a pamphlet issued by O. S. Walker & Co., Worcester, Mass. The catalogue illustrates the various types of surface grinders, planers and rotary magnetic chucks now largely used in the up-to-date shop.

Views showing the application of an aerial wire-rope tramway to the transportation of ore for the North American Copper Company, in Wyoming, over a distance of 16 miles, with a description of its operation, are contained in a pamphlet issued by the A. Leschen & Sons Rope Company, St. Louis, Mo.

The Crane Company, Chicago, has issued a circular calling attention to the main points of the Crane pop safety valve. The special features of the self-adjusting auxiliary valve and spring, the encased spring valve, and the composite marine pop valve are briefly described, as are also those of the self-adjusting pop regulator.

Sewing machine motors are the subject of a pamphlet recently issued by the General Electric Company, Schenectady. The motors illustrated and described are both direct current and induction, and are adapted for a variety of uses in light work.

A very comprehensive book of supplies for foundrymen and pattern makers has been prepared by the S. Obermayer Company, Cincinnati.

The Sederholm horizontal tubular boiler, built by the Allis-Chalmers Company, of Chicago, is described in a new catalogue sent out by that company.

The Parsons steam turbine, as made by the Westinghouse Machine Company, East Pittsburg, Pa., is described in a new catalogue just brought out by the makers. It illustrates several installations of turbo-generators, and views are also given of several details of the turbine.

The Kellogg Switchboard & Supply Company, Chicago, has supplemented its previous catalogues of telephone supplies by one of magneto-switchboards. The catalogue contains illustrations of switchboard connections, and also directions for cable forming and splicing.

"A Clean Chimney" is the cover title of an attractive booklet circulated by the Peabody Coal Company, Chicago. The economical burning of coal without smoke is discussed by A. Bement in this publication, which should prove of no little interest to engineers and to all consumers of coal for industrial purposes.

The Murray Iron Works, Burlington, Ia., are sending out a new catalogue of Corliss engines. The several types of boilers are illustrated and described, as are also the feed-water heaters and air compressors as built on the Murray design.

The distinguishing features of design of alternators and direct-current generators, as built by the National Electric Company, Milwaukee, Wis., are set forth in separate catalogues published by that company. The various types for high and low tension and for direct-current work are illustrated throughout and the details fully explained.

The Foster superheater is treated of in a pamphlet recently sent out by the Power Specialty Company, of New York City. In addition to the description of this form of superheater, the pamphlet contains much valuable information on the subject of superheated steam generally.

The most attractive trade publication of the year is, without doubt, the recently issued pamphlet of the Westinghouse Electric & Mfg. Co., dealing with the industrial and sociological aspects of the Westinghouse works. The purpose of the little book is not to tell anything about the various inventions which have been brought out under the Westinghouse name, but to tell something about the mammoth electric manufacturing plant at East Pittsburg, and in that respect it accomplishes its mission in a most admirable way. The engravings are splendidly executed, and the typographical excellence throughout is of the first order.

A coin-receiving device used at the entrance of the St. Louis Fair, in connection with the ordinary registering turnstiles, is so aranged that the turnstiles will be locked except when a proper coin is placed in the machine, when it admits one person, automatically locking again until the next coin is placed in it.

Electroplating upon Aluminium

ELECTROPLATING upon aluminium has been the subject of not a few contributions to the technical press, the latest literature along this line being the result of investigations conducted at the University of Wisconsin, published in "Electrochemical Industry" of recent date. The mode of operation recommended is to first clean the aluminium by immersion for a few minutes in a dilute hydrofluoric acid bath, where it remains long enough to produce a suitable roughening of the surface. The deposition upon a rough surface is more adherent than upon a polished one, and this step is therefore of importance. Upon removing the aluminium from this bath it is rinsed in running water and then dipped for a few seconds in a mixture of 100 parts of sulphuric acid and 75 parts of nitric acid, both concentrated, from which, after rinsing in water, the aluminium comes perfectly white and clean. If an impure aluminium or aluminium alloy be treated, it may have a loosely adhering black coating on leaving the hydrofluoric acid dip, and this may be removed satisfactorily by brushing before placing it in the final acid dip.

The aluminium after being thus cleaned is transferred to the zinc plating solution. This consists of a mixture of zinc and aluminium sulphates in the proportion commonly used for zinc plating, very slightly acidified and having a density of about 15 degrees Baume and containing about 1 per cent. of hydrofluoric acid or an equivalent amount of potassium fluoride.

While it is desirable that the article be transferred from the cleaning solution into the plating bath without unreasonable delay, it is not essential that it be done with great rapidity, since the plating solution acts also as a cleaning one. After the deposition has proceeded for about ten or fifteen minutes with a current density of from 10 to 20 amperes per square foot, the article may be taken from the solution and dried. It may then be given a coating of copper or silver from their cyanide solutions, using such precautions as are commonly observed in the deposition of such metals upon zinc.

Where the final coating is to be of gold, it may be advantageous to polish the copper coating before depositing the gold, as otherwise a thicker gold coating will be necessary to produce the final polish.

In the work of boring the Simplon tunnel somewhat over 11¼ miles have been completed, leaving slightly less than a mile yet to be finished.

A NIGHT VIEW OF FESTIVAL HALL AND THE COLONNADE OF STATES AT THE ST. LOUIS EXPOSITION

SUPPLEMENT TO "THE ELECTRICAL AGE," JUNE, 1904.

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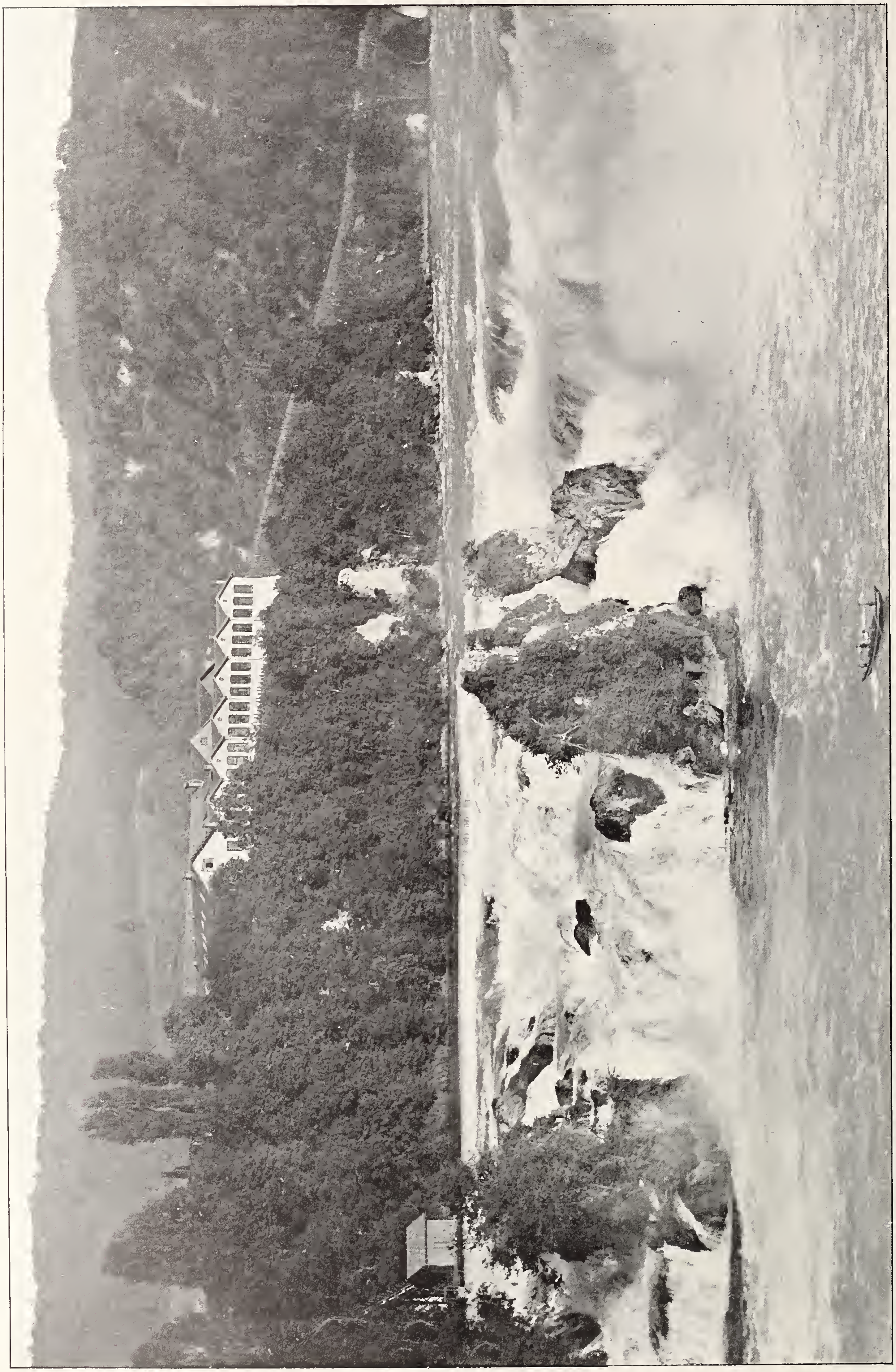
Large Water-Power Electric Installations

By DR. F. A. C. PERRINE

From a Paper Read before the National Electric Light Association.

THE development and use of the waterfall is a subject not only of vital industrial importance, but also one of fascinating interest. Whatever charm the subject may have generally, it is much more worthy of attention and more picturesque when viewed from the standpoint of electrical development, which goes hand in hand with a preservation of the scenic effects, while affecting important social and industrial improvements. Young men have been the pioneers in this industry, and are yet to-day among its

AN ANCHORING PIER ON A MOUNTAIN SIDE PIPE LINE BELONGING TO THE HYDRAULIC PLANT OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA



THE FALLS OF THE RHINE AT NEUHAUSEN, SWITZERLAND. THREE THOUSAND HORSE-POWER ARE HERE DEVELOPED AND USED IN THE MAKING OF ALUMINIUM

HIGH-TENSION TRANSMISSION LINE LEAVING THE POWER HOUSE AT ELECTRA OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA

THE LOWER PORTION OF THE MAIN PIPE LINE OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA

foremost workers. There has been no region too remote and no problem too difficult for their energies and ambition.

But before attempting to present the picturesque view of this work that is so intensely interesting from every side, it is well to stop and consider why we should be especially proud of the work that has been done, beyond the pride that we feel in winning success for ourselves and taking part in making nature do our work for us. Without thought, it is often the custom of some to consider and arraign the development for power purposes of the streams of a country as but a form of industrial vandalism. Such a belief or feeling can now be held only by the thoughtless and unobserving. John Ruskin, during many years of his life, bitterly arraigned the commercialisms of his day, blaming mechanical inventiveness and progress for what he saw about him worthy of blame. He undoubtedly placed his finger on many sore spots in our day of progress, and about his teachings a school has developed which has accomplished much in spite of the fact that many of his fears and forebodings were groundless. The hideous characteristic of commercial growth about which he complained was but one of the accompaniments of new growth, for to-day we cannot call modern commercial, industrial and mechanical progress old.

One hundred years is surely a short period in the world's history, and yet the birthday of the steam engine as applied to manufacture dates back only to the spring of 1786. The first fifty years of the nineteenth century marked the introduction of all we know as manufacturing, while the last fifty years of that century developed practically all of the machinery we use to-day. Is it strange, then, that accompanying the birth of so many new ideas, and being engaged in their rapid development and introduction, those concerned with this work should use the machinery first in the crudest and most temporary manner, hesitating to build and plan as though in the belief that what they were doing was other than experimental?

With much of the crude mechanical application completed, we are now during the present century devoting our time and talents and using our opportunities for the development of the comfortable and artistic. Surely, no one who has for any period of time considered the products of manufacture can fail to notice and acknowledge this advance.

The electrician has come forward with his inventions in hand to remove the factory from the bank of the stream to a location where the health and comfort of the operative can be considered, and he has established the factory where there is a possibility of lifelong occupation with less of dirt and danger than ever could have been accomplished in any other manner. Beyond the factory, too, the influence reaches far, for in the development of every horse-power of water energy made available by such means, there are at least 12 tons of coal less per year that it is necessary to mine for doing the world's work; by reason of each of the 1000-H. P. generators that the electrical companies are sending out every year in numbers there are 12,000 tons of coal less to be mined per year, and not for one year only, but for every year the machine continues in operation. The waterfall has been called the white coal mine; the miners, the stokers; the coal passers being the sun, the winds and the rain which continually replenish the river's source.

Not only in its generation, but in its application, is the electrical development of the water-power important. It surely must be evident to all how important an element in the disintegration of the crowded and squalid portions of cities is the extension of electric traction, and, further, the use of electrical power that may be distributed to great distances and applied in small quantities is rendering the small manufacturer more independent of the large one, an effect which in our country is only just becoming apparent and important, but which in some localities (as notably at Geneva, Switzerland) has had a marked effect on the character of trade, and has enabled the home-worker to continue in competition with the factory. Do not think that what has been said is an apology for electrical water-power development. On the contrary, it has been said in the hope of calling to your attention neglected facts that are about you and the importance of work that has been done in your midst.

The development, transmission and distribution of the power of the waterfall have resulted from the continuous study and work of the electrical discoverers, inventors and engineers during a period of about seventy years, every year of which has been important to the result attained, though the last ten years have produced the most striking of the practical results. During this period the advance has been so rapid as to astonish even the most sanguine and enthusiastic prophets of advancement.

The art of the electrician, as we know it to-day, began in 1832, when Faraday, working in his laboratory at Cambridge, England, discovered the principle of the production of electricity from magnetism, and laid the foundation for the invention of the dynamo-electric machine. In the year following, at Albany, N. Y., Joseph Henry discovered the principles that are now embodied in the transformer, and with the foundations for the art thus laid, the inventions began.

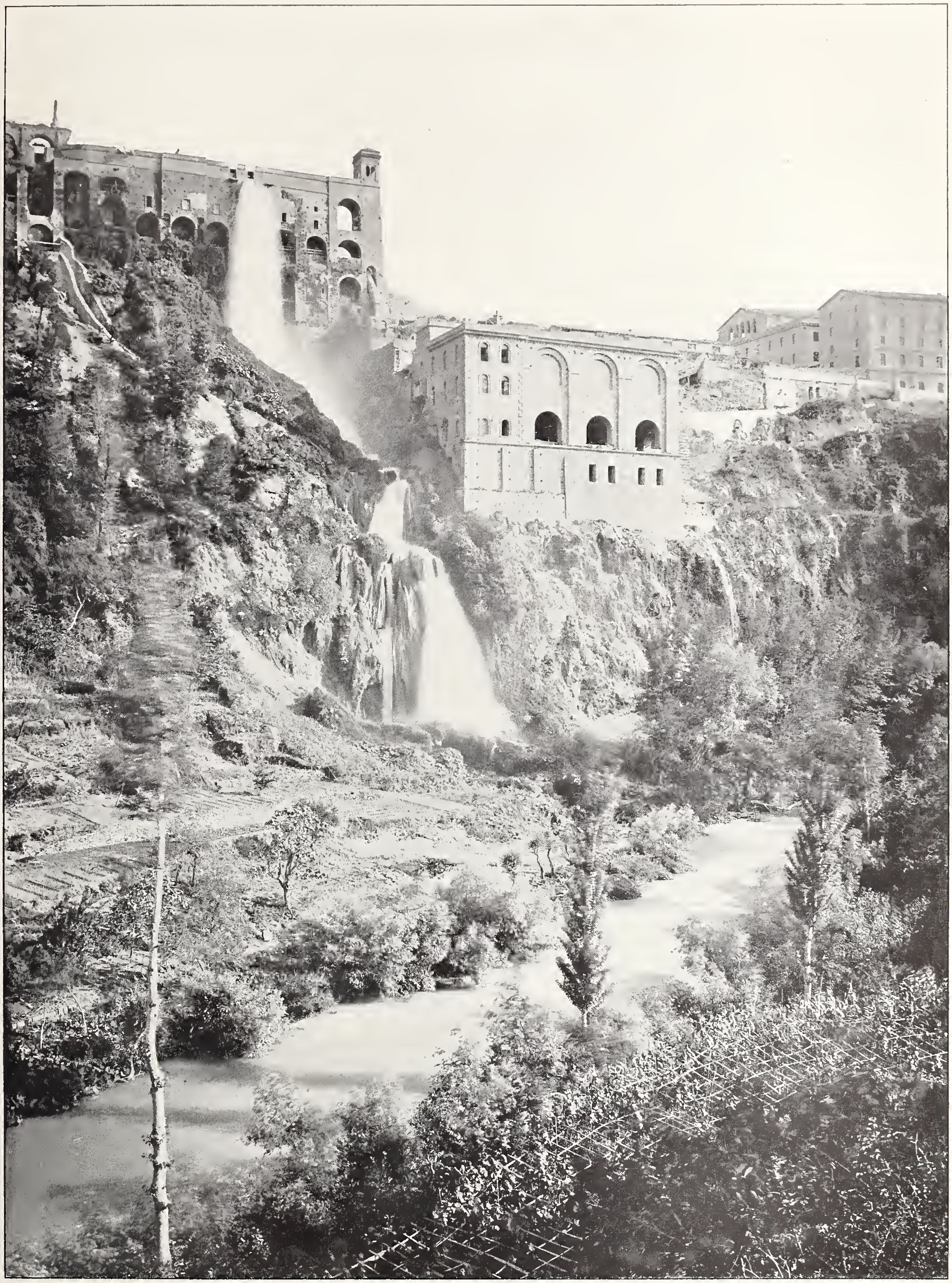
Gradually the machinery has developed, until suddenly and accidentally the reversibility of the dynamo was discovered at the Vienna Exposition of 1873, and the whole field of electric-motor working was opened up, for the reversed dynamo is the motor. Then began the study of the application of electricity as a motive power. In the early days attention was being given almost exclusively to lighting problems, and it was not until the early eighties that the motor became a really important machine. About that time in California, in Switzerland and in Northern Italy, beginnings were made in the electrical use of the waterfall, but the present solution of the long-distance problem has been based upon the discoveries of Ferraris in the later eighties. The work of this Italian pointed out the manner in which the alternating motor could best be made, and how that beautifully simple generator, the alternator, which has no sparking commutator, and if necessary no moving wire, could be utilized for power purposes.

Furthermore, the experiments of Henry and his successors had shown how the pressure of the alternating current could be raised or lowered without moving apparatus, and this resulted finally in the development of the simple transformer.

The first American plant utilizing all of these elements was installed by the Stanley Company at Housatonic, the current being transmitted to the Monument Mills and Great Barrington. This was in 1893. From these small beginnings the art has rapidly advanced, the engineers and inventors working together and vieing with each other, till now there seems no problem too difficult or startling for them to attempt together.

The most startling and picturesque work has been carried out on the Pacific Coast, a land of no coal and little water, but in which the rivers flowing to the sea descend with most startling rapidity, permitting the development of great powers from insignificant streams. Over and through the central part of the State there runs a network of transmission lines fed by machinery designed and manufactured in Pittsfield. In this region many falls have been utilized, and the current is transmitted to great distances for the operation of lighting

THE ELECTRIC STREET RAILWAY AND LIGHTING SERVICE OF ROME IS SUPPLIED IN LARGE PART FROM THE FALLS AT TIVOLI, SEVENTEEN MILES AWAY, WITH AN AVAILABLE HEAD OF 360 FEET



THE HYDRAULIC POWER HOUSE AT TIVOLI

"LEADING" THE JOINTS ON THE PIPE LINE OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA. THE FURNACE AND TRUCK TRAVELED ON TOP OF THE PIPES, USING THEM AS TRACKS

plants, railroad and mills. Here the season of practically no rain is long and must be guarded against by the storage of water in the mountain lakes of the high Sierras at elevations of from 6000 to 9000 feet. From these lakes the water falls into the bed of the rivers where it flows among the high mountains and through the deep canons until it is caught and carried along the mountain sides through ditches and along the face of high precipices in timber flumes, until a point is reached where the difference of level between the ditch and the river is sufficient, and the site favorable for the location of the power house, when with a bold leap the water is carried in iron pipes down the mountain side to the power house, where with immense force it plays on the buckets of the wheels in a stream of great power. These jets of water, spouting under pressures of from 300 to 700 pounds per square inch, seem now to have almost lost the character of ordinary water and to have become a different substance.

Nothing built will resist the terrible tearing force they develop. The moving mountains and the filling of rivers and harbors is a tale familiar to all from the stories of mining days, but even a knowledge of this does not enable one to realize the force so much as does the fact that these jets will wear away and tear apart riveted shells of boiler iron; a stream no larger than your smallest finger will pierce and kill a man as quickly almost as a shot from a gun; the skin will be stripped from the hand if laid for an instant along the side of the stream, and a stone or board thrown into it will rebound as from a surface of rubber, it being thrown many feet away.

The scenes about these power houses are of great beauty, and are filled with many spectacular features. As one approaches one hears coming up the canon a continuous humming sound as of many bees, for the machines that one sees here in the power house once in operation are running continuously for weeks and months at a time. One can hardly realize that in this bright power house, with no confusion or dirt, and little evidence of what one ordinarily associates with machinery, current is being generated for the operation of lights and cars and mills in cities many miles away, where annually the use of many thousands of tons of coal is being displaced.

In some ways the transmission of the current presents more startling feats of engineering than the generation of the current itself; poles, wires and insulators must be brought many miles into the mountains, distributed at inaccessible spots over a hostile country, and then after a right of way has been cleared through the forests the task of erection requires great skill and the ability to overcome obstacles of startling variety. At times the poles must be set in river beds by cementing to mounds of rock so that they will not be carried away during the spring floods; at other points the line must be swung across canons, at times in spans exceeding one-quarter of a mile in length, and always stretching away over hills and valleys to the far distant city in a course as straight as possible. This is no haphazard work such as is often seen in the construction of the telegraph and telephone lines about us here, for the success of a transmission plant depends upon the permanence and continuity of its service, for the attainment of which the greatest precautions are taken in the clearing of the right of way and providing for a continuous patrol, inspecting and guarding the lines.

In the cities themselves simple substations are used for the distribution of the current, where often large amounts of power are made available without any accompaniment of dust or dirt and in a space much less than could avail for the steam engine doing a similar amount of work.

On the Pacific Coast nothing is considered high head when the pressure is less than 100 pounds per square inch, representing a fall of water of about 200 feet, and from such heights the heads increase to a maximum of about 2000 feet, which represents almost the maximum in the developments accomplished up to the present time.

It will be interesting now to examine one that is almost the extreme in the opposite direction, and for that purpose we will take a glance over the plant at Sault Ste. Marie, Mich. To be sure, the financial difficulties of the company developing this power have lately attracted much attention, but we are now discussing engineering and not finances. Of engineering of a high order there has been no lack at the Sault.

In carrying the water of Lake Superior around the St. Mary's Rapids to the power house below them, where the small head of 18 feet is being utilized, one of the deepest and widest canals of the world has been built, 25 feet deep and 210 feet wide. This canal curves around the back of the town, emptying into St. Mary's River through the power house which has been built across the forebay at the end of the canal, the house itself being 1465 feet long, over a quarter of a mile. In this great power house eighty small generators, each of 400 H. P., are set, each being directly coupled to four water-wheels set without any flumes or pipes directly in the waters of the forebay itself.

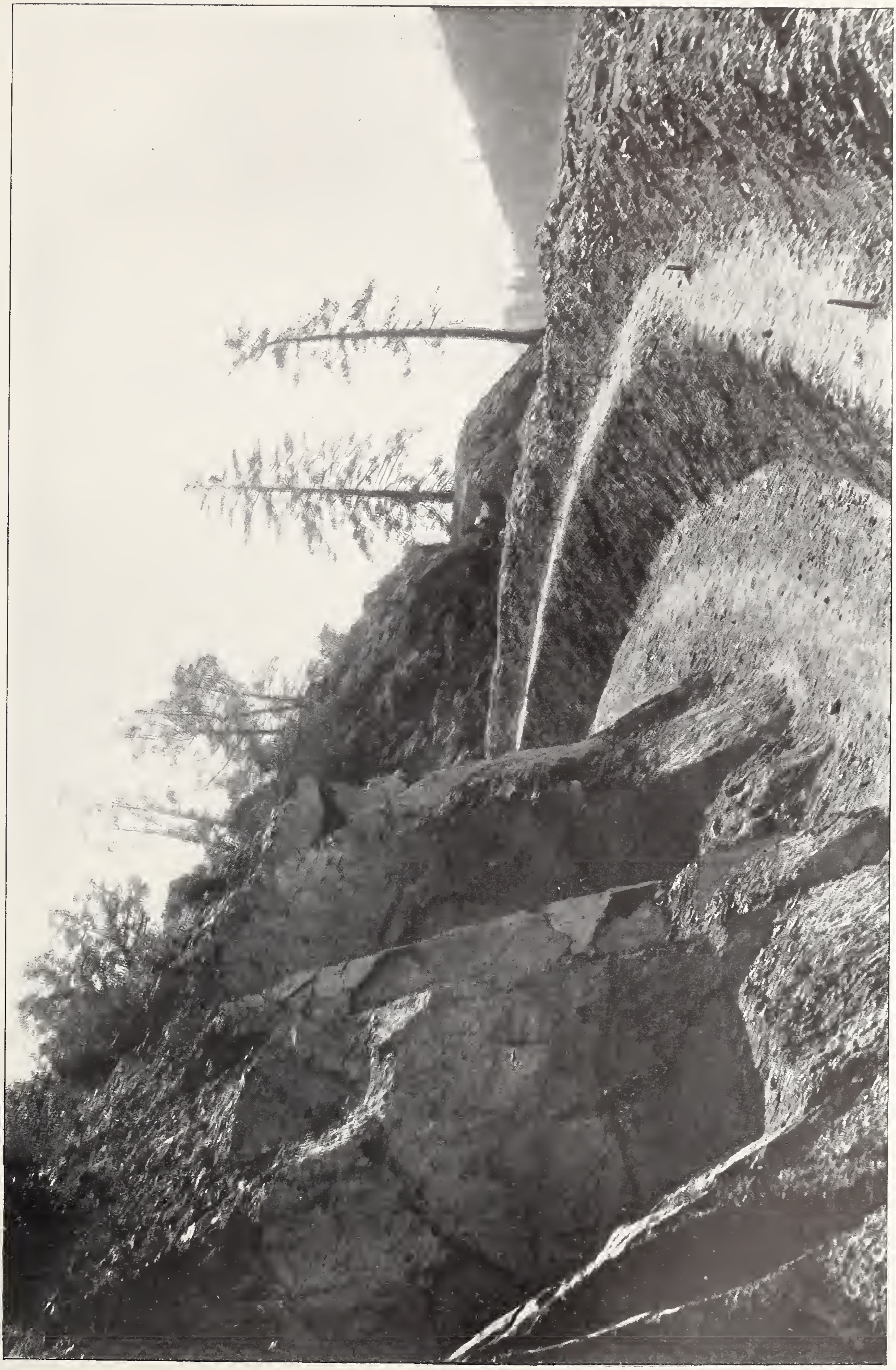
The difficulties encountered in the development of this great power plant have been those of handling such a great volume of water, but, in spite of the great difficulties that have been met, the cost of the whole work has not been excessive, and when this plant is entirely completed there need be no fear of drought or flood, for from that greatest of storage reservoirs, Lake Superior, the flow at all seasons is remarkably constant, and at times sufficient for the generation of above 100,000 H. P.

Some of the most beautiful natural scenery surrounding power developments is to be found in our neighboring State of Mexico. There the characteristic plant is one with a diverting dam in the river, a large canal along the mountain side, and a water head at the wheels of from 80 to 100 feet. The work done in Mexico is of a surprisingly stable character; in every point of detail the extensive use of hand labor is made manifest, whether in dams, canals or power houses, all of which is warranted by the fact that the fuel supply of Mexico is severely limited and the prices paid for power make large returns in revenue upon the investment in the power plants.

Let us not think that the development that has been made covers either the needs or the opportunities of the present day or that the installations now being undertaken are simply those of which consideration has been previously suspended on account of more favorable opportunities of power development at other locations. On the contrary, among the developments now being studied are some of whose importance there has been an early appreciation. It is true that by reason of the advancement in electrical machinery for the development, transmission and utilization of energy, there is now a possibility of larger stations than in any previous period of the world's history, and, furthermore, the question of accessibility and nearness to market is less important than heretofore; since there is now almost no limit to the size of development that may be successfully undertaken, though ten years ago there was hardly a 5000-H. P. water-power plant in the country, and to-day transmission distances up to 25 or 30 miles are considered short.

At present engineers are engaged upon the studies for a plant of great magnitude on the Potomac River, at the very point where George Wash-

TWO THOUSAND MEN WERE EMPLOYED IN DIGGING THE DITCH OF THE STANDARD ELECTRIC COMPANY



THE FINISHED WATER-POWER DITCH OF THE STANDARD ELECTRIC COMPANY OF CALIFORNIA PRIOR TO ADMITTING WATER

ington was engaged as a civil engineer before he entered Braddock's army.

The great falls of the Potomac operated flour mills before the revolution, and Benjamin F. Butler devoted much of his time and money toward securing control of all the power rights, leaving to his heirs a property that soon will be utilized in operating the lights and railroads of the city of Washington. The great falls of the Potomac River present engineering difficulties on account of the great fluctuations in the flow of the stream and on account of the peculiar fact that below the falls the river enters a narrow gorge about 2 miles in length where, during flood periods, the variation in the river's depth is as much as 60 feet. Only after continued study of the situation has a plan been evolved overcoming these difficulties by running a long canal and tunnel completely around the gorge and locating the power house at a point where the river widens and the ebb and flow of the flood waters is not great.

I trust that I have here given some slight idea of the problems that engineers have overcome, and have, at the same time, given some insight into the fascinating side of their work, facing nature in all her moods—facile, fickle and wild—and ever benefiting those abroad as well as those at home for all the future.

The Electric Steel Furnace at Gysinge, Sweden

By F. A. KJELLIN

A Paper Read before the American Institute of Mining Engineers

THE problem of smelting steel by electricity attracted the attention of inventors years ago, and as early as 1879, C. W. Siemens constructed his first furnace for the smelting of metals, especially steel. This furnace was of the arc type in which the voltaic arc was formed between a carbon electrode and the metallic contents of a crucible, the length of the arc being regulated by an electromagnetic device.

This electric furnace, as well as others of similar construction, has the inconvenience that the source of the heat—the voltaic arc—possesses a temperature of 3700 degrees C., which is much more than that required by steel smelting. The result of the use of this intense heat is that the steel is overheated in the vicinity of the arc, while in other parts of the furnace it is still at a relatively low temperature. Another inconvenience is that the steel very easily takes up impurities from the electrodes consumed.

The cost of the electrodes also is an item that sensibly increases the cost of production, and the carbon monoxide resulting from the oxidation of the electrodes exerts a bad influence, as it prevents the steel from giving off the carbon monoxide dissolved in it. A more uniform heating of the steel can be obtained by passing electric currents of great intensity through the steel, and using the heat evolved by the resistance of the steel for the smelting. But as the resistance of metals, even when molten, is comparatively low, the currents used must be so great that copper cables get a section at least as great as that of the steel in the furnace.

Mr. de Laval, the well-known Swedish inventor, has tried to diminish this inconvenience by using molten slag instead of steel as resistance in his furnace; but the results cannot have been satisfactory, as the patent has been allowed to expire.

The greatest difficulty in electric furnaces of this kind comes from the electrodes, for the reason that carbon electrodes have high resistance, cause great losses of tension and power, and are soon consumed at the contact with molten steel. Water-cooled iron electrodes could possibly be used, but then the magnetic properties of the iron create new difficulties. In order to get sufficient intensity of current, alternating-currents must be used, and then the magnetism causes the concentration of the current at the surface of the electrodes (skin effect), and the result is great current density in the electrodes with great losses of power, and by the influence of self-induction a diminished capacity of the electric generator to convert mechanical energy into electric energy.

In order to eliminate these difficulties I proposed to Mr. Benedicks, general manager of the Gysinge works, in May, 1899, to build an electric furnace at Gysinge, without electrodes. My project was accepted and I went to Gysinge to carry it out.

The cut on page 357 shows the principle of the furnace. An annular groove, *AA*, forms the furnace room, the sides and bottom of which consist of refractory bricks. The covers *B B*, close the furnace. In the center of the circle formed by the furnace room is a triangular core or cone, *C*, formed of thin insulated copper wire, which continues outside the furnace and forms with the furnace room the two links of a chain. The coil, *D D*, is connected with the poles of an alternating-current generator.

When passing through the coil the current excites a varying magnetic flux in the core or cone, and the intensity of current in the steel is then almost the same as the primary current multiplied by the turns of wire in the primary coil. The tension of the current is naturally reduced in almost the same ratio as the intensity is increased. In this way it is possible to use an alternating-current generator of high-tension, and yet obtain a current of low voltage and great intensity in the furnace, without using transformers with copper cables of large sections and powers and costly electrodes.

In February, 1900, the first furnace at Gysinge was ready for use, and by March 18, the first steel ingot was cast, which from the beginning was of an excellent quality. The problem was then solved technically, but not economically, for with an electric generator of 78 K. W., only 600 lbs. of steel were produced in twenty-four hours.

The next furnace built was ready in November, 1900, and produced with 58 K. W. from 1300 to 1500 lbs. of steel ingots in twenty-four hours. The charges were composed of 220 lbs. and the time between the casts from three to four hours. The output was not fully satisfactory, because the cooling surface of the walls was too great compared with the contents of the furnace, and the cost of repairs was also rather high.

On August 11, 1901, the sulphite pulp mill of Gysinge was completely destroyed by fire, and it was then resolved not to rebuild it, but to use for steel smelting the water-power formerly absorbed by it.

The new plant was ready to start in May, 1902, and has since that time worked satisfactorily. It consists of a furnace containing 4000 lbs. of steel from which from 2200 to 2400 lbs. are taken out by each tapping and the rest is left to keep the current passing. The furnace produces with 165 K. W. or 225 E. H. P., 9000 lbs. of steel ingots in twenty-four hours when charged with cold materials. The electric generator gives alternating single-phase current of 3000 volts, which is directly transformed by means of the primary coil and iron core (cone) of the furnace, into a current of about 30,000 amperes in the

steel that forms the secondary circuit.

The smelting process, as carried on at Gysinge, where only first-class steel is produced from the excellent Dannemora pig iron and weld iron, is as follows:—

After casting, about 1700 lbs. of metal are left in the furnace to keep the current passing, and to this are added the proper quantities of pig iron, bar ends and steel scrap as experience has proved will give the percentage of carbon desired in the resultant steel.

There is always less carbon in the steel than that contained in the materials charged, for the reason that the pig iron is rusty and the steel also takes up a little silicon by reduction of the silicic acid of the lining. When the charge is molten and overheated to a suitable degree, the tapping is done in the same way as in the open-hearth furnace, by making a hole in the wall. The upper part of the furnace, as shown in the cut, is on the same level as the working floor, and the charging is done simply by taking off the covers and putting in the materials. As the heat is produced in the steel itself, the slag is not so hot as in the other steel furnaces, and consequently the workmen do not suffer much from the heat. The steel produced is, as mentioned above, of an excellent quality, uncommonly dense, unusually homogeneous and tough, easy to work cold when annealed, and less disposed to crack and warp in hardening than other kinds of steel. I think that the cause of these excellent qualities, apart from the good raw materials used, must be due to the fact that the product contains less dissolved gaseous matter than other kinds of steel.

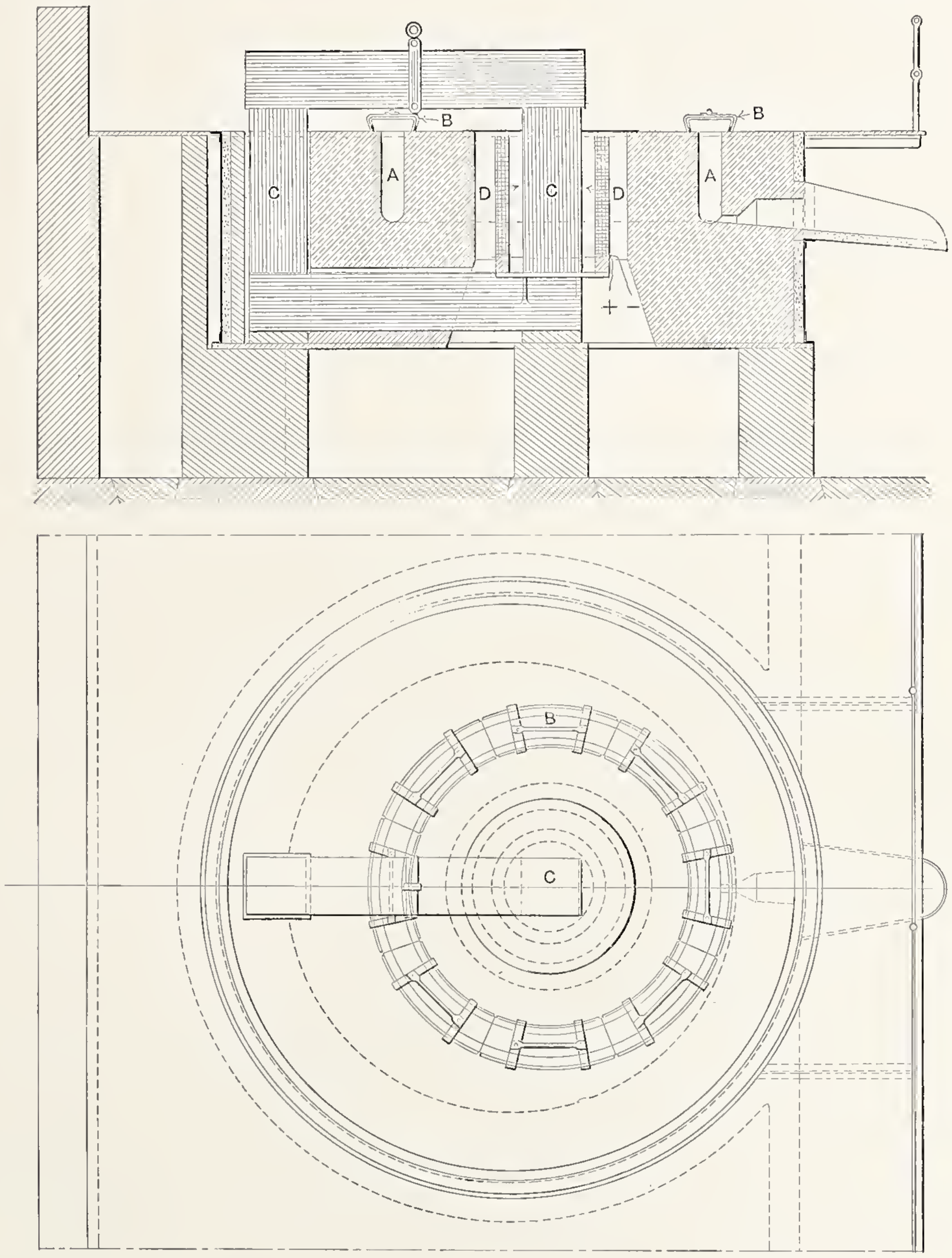
As every one knows, even small quantities of gases, especially hydrogen, injure the quality of steel, and the principal cause of the high quality obtained by smelting in crucibles is, in my opinion, that the steel is not in contact with the fuel gases, though it may absorb a little through the porous walls of the crucible. In the electric furnace described above, the steel has no opportunity to take up such gases or other impurities, and the quality is even better than that of crucible steel with the same analysis.

To make special steels with nickel, tungsten or chromium offers no difficulties, and the alloys themselves are quite homogeneous. The cost of production depends principally on the efficiency of the furnace and the price of the power. In the furnace now in use at Gysinge the losses have been proved experimentally to be 87.5 K. W., so that the effective power absorbed by the steel is 165 — 87.5 = 77.5 K. W.; and, as those produce 9000 lbs. of steel in twenty-four hours, 1 effective K. W. produces 116 lbs. of steel ingots in the same time. Every additional kilowatt in the furnace, when the size is not altered, increases the output by 116 lbs., and it is calculated that within a few months, when a stronger water-wheel is obtained, to produce about 13,000 lbs. of steel ingots with 200 K. W.

As the absolute cost of labor and repair will be the same, those costs for 1 ton of steel ingots will be about two-thirds of the present cost, and the price of power per ton also will be sensibly diminished. At Gysinge the cost of repair (renewing the lining of the furnace when it is worn out) was $60.

From experience with this furnace it is calculated that a furnace of 736 K. W., or 1000 E. H. P., will produce 66,000 lbs. of steel ingots in twenty-four hours, when charged with cold materials. With hot materials the output is much greater. For instance, if 550 lbs. of molten pig iron are charged for each ton of steel ingots produced, the output is increased from 66,000 to 80,000 lbs. in twenty-rour hours, with 1000 E. H. P.

In my opinion, the costs of labor and repairs for a furnace of this type will be less than those of an open-hearth furnace of the same size, so that, where power is cheap, there is a possibility of producing a steel competing with the expensive crucible steel at a smelting cost not exceeding that made in the open-hearth furnace.



A TRANSVERSE SECTION AND PLAN OF THE KJELLIN ELECTRIC STEEL FURNACE AT GYSINGE, SWEDEN

A Cincinnati concern is manufacturing a motor-driven ice cream freezer. The motor and starting rheostat are mounted on a solid base, upon which is also secured the freezer geared to the motor. The motor is placed on cans having a capacity as low as 25 quarts.

Special Structures on Transmission Lines

By ALTON D. ADAMS

TRANSMISSION circuits of high voltage should be given the highest positions on their pole lines, and the other wires, if any, should be strung from 5 to 10 feet underneath. In cases where a transmission line must cross circuits of relatively low voltage, the poles that carry the high-tension wires should be high enough to keep them from 10 to 20 feet above the other circuits.

When a transmission line is run across a belt of timbered country all tree limbs that overhang the wires should be removed, and it is also desirable, where practicable, to cut down all trees that by falling might strike the line. Circuits should be distant as much as 10 feet if possible from the sides of buildings generally, and at least twice this distance from their tops.

In cases where the high-voltage line crosses a steam railway, extreme precautions are often required. Such precautions may take the form of extra high poles and of special overhead construction, or even of underground cables. Thus, at Saratoga, N. Y., where two 30,000-volt circuits from Spier Falls cross the tracks of the Delaware & Hudson Railway, two poles are set at each side of the right of way, so that the plane of each pair is at approximately right angles with the direction of the wires.

Each pair of poles is placed with the poles about 9 feet apart and carries three sets of double cross-arms. The top pair of cross-arms is 16 feet long; six feet below there is a pair 14 feet long; and midway between these top and bottom sets is a pair of 10½-foot cross-arms. Each of the top cross-arms carries six insulators; each intermediate arm has two insulators; and each of the bottom arms four insulators. On the four intermediate insulators of each top cross-arm, and on the two insulators of each intermediate arm, the six wires of the two three-phase circuits were strung.

Between the end insulators on the two pairs of top cross-arms, and between all the insulators on the two pairs of bottom cross-arms, galvanized iron wires were strung over the railway track. At intervals along these wires crossing the railway they were united by other wires at right angles to their length, so that a mesh or net of iron wires was formed about the sides of and underneath the 30,000-volt circuits. Should one of the high-voltage wires fall, it is almost certain to be caught by the net of iron wires, and thus held clear of the railway.

At one point in St. Paul, Minn., two 25,000-volt three-phase underground cables that carry the electrical energy transmitted from Apple River Falls, between the terminal house and the sub-station, cross a deep railway cut. For this crossing a brick well about 50 feet deep is built at the end of the conduits on one side of the tracks, and from the bottom of this well conduits are laid to the bottom of a similar well on the opposite side of the tracks. The two cables leave their conduits at the tops of these wells and drop vertically to the connecting conduits beneath the tracks.

At a railway crossing of the 13,000-volt line of the New Hampshire Traction Company, at Portsmouth, N. H., the overhead wires were required to go underneath the track. For the purpose of this crossing a brick terminal house was erected on each side of the track, and in these terminal houses the overhead lines joined the short stretch of underground cable.

Sometimes it is convenient to attach transmission lines to a railway or other bridge in crossing a river, and in such cases it is desirable to carry the lines over the top of the bridge, or at least on one side, rather than underneath.

The two three-phase circuits between Apple River Falls and St. Paul, which operate at 25,000 volts, cross the St. Croix River over a railway bridge at a point where the river is about half a mile wide. Supports for the wires are provided at intervals of 50 feet by oak timbers that are inserted between the ties and extended horizontally to a distance of 20 feet beyond the side of the bridge. The six wires are carried over these timbers in a horizontal plane, and are spiraled three times in the width of the river to avoid inductive effects that would be increased by the iron of the bridge.

Another instance of transmission lines on a railway bridge is that of the 25,000-volt circuits from Chambly, Que., which cross the St. Lawrence River at Montreal over the top of the Victoria Bridge. The twelve wires of the four three-phase circuits in this case are carried on timber fixtures that rest on the top of the bridge, and mutual induction between them while over the steel trusses is dampened by several transpositions of each circuit.

The line just named crosses the Richelieu River a short distance below the power station at Chambly on two-pole lines set a few feet apart in the same concrete piers. There are six of these piers; each span between them is approximately 125 feet in length, and each pole carries its six wires on two pairs of double cross-arms. As there is no navigation on the river at this point, it is not necessary to carry the wires very high at the river crossing, and the poles set in the concrete piers are about 35 feet long.

A short distance from the river crossing just mentioned, the 25,000-volt line passes over the Chambly Canal, which affords water transportation between Lake Champlain and the St. Lawrence River. Two steel towers were erected on each side of this canal to carry the transmission lines above the reach of shipping. Each of these four towers has a height of 144 feet above its foundation, the length of span between the towers is 132 feet, and the lowest of the twelve conductors supported by the towers is more than 131 feet above the water level. On each tower there are three sets of four-pin cross-arms, the cross-arms in each set being in the same horizontal plane, so that each conductor is supported by four insulators on each tower.

In order to reach the Island of Montreal, the 50,000-volt three-phase circuit from Shawinigan Falls crosses the Ottawa River at a point about 14 miles from the city of that name. This crossing is made by spans that are 1200 and 1850 feet long, respectively, and which are supported on four towers 90 feet high. Instead of the three aluminium cables that form the regular transmission circuit in this case, three steel cables of 1-inch diameter each are used for the long spans across the river. It was possible in this case to divide the river crossing into two spans, because of an island in the middle of the stream.

The most notable instance where a high-voltage transmission line makes a long span at a great elevation in order to avoid shipping, is that of the 60,000-volt circuit between Colgate power house and the city of Oakland, Cal., which crosses the Carquinez Straits by a single span 4,427 feet long and not less than 200 feet above the water. These straits join Suisun Bay, into which the Sacramento, the San Joaquin and other rivers empty, with San Pablo Bay and the Pacific Ocean.

Two three-phase circuits extend from the Colgate power house to the shores of this bay, but the crossing is made by four steel cables with a diameter of $\frac{7}{8}$ inch each, three of these cables being used to form a single three-phase circuit, while the fourth cable is held in reserve. Each of these four steel cables has a dip or sag of 100 feet between the towers on the opposite banks of the straits, is supported at each tower on steel rollers, and is secured behind the respective towers to anchorages 6200 feet apart. The towers thus sustain merely the weight and downward pull of the steel cables, and the direct strain of each cable is sustained by its anchorage at each end.

The tower on the south bank is 65 feet high, and the tower on the north bank is 225 feet high, above the foundations. Although the straits are only about 3200 feet wide at the point of crossing, it was thought desirable to locate the towers some distance back from the banks in order to save in the height of the towers, and the distance between them was thus increased to 4427 feet. The north tower was located on land that has an elevation of 160 feet above the water level, so that the top of this tower stands 385 feet higher than the water surface of the straits.

A still higher point was selected for the location of the tower on the south shore, and the required height of this tower was thus reduced to 65 feet above its foundation. Each of the four steel cables is supported at each tower by a pair of 9 by 18-inch square timbers that extend out horizontally from the tower, so that the cable is 8 feet distant from its side. There are four pairs of these timbers on each tower,—one pair at the top, another pair about 26 feet below, and the other two pairs spaced at equal distances in between. These pairs of timbers project alternately on opposite sides of each tower, so that the two pairs on the same side of each tower are about 13 feet apart, giving the higher cable on each side an elevation of 13 feet above the one beneath it.

The weight of the $\frac{7}{8}$-inch cable in each span is 7.08 pounds. With its sag of 100 feet between the tower supports the strain on each steel cable is 24,000 pounds, and as its breaking strain is guaranteed to be 98,000 pounds, the factor of safety is 4. Each cable at each tower rests on five steel sheaves that are mounted so as to turn in a cast-iron saddle and thus allow a movement of the cable to compensate for expansion and contraction. Each of these sheaves is about 6 inches in diameter, and the cast-iron saddle in which the five sheaves of each group are mounted is about 40 by 14 inches. The saddle is bolted to a timber platform approximately 46 by 56 inches on top and 12 inches thick. Six porcelain insulators of special design support this timber platform and are let into its under side to a depth of about 6 inches. Each of these insulators is made up of three parts, cemented together with sulphur; the diameter of the petticoat of the outer part is 17 inches, and there are two smaller petticoats underneath.

A steel pin is cemented into each of these insulators with sulphur, and the outer petticoat of each insulator is about 9 inches above the cross-timber that carries its pin. Three of these cross-timbers, each carrying two of the insulators, are employed to support each platform, and their ends rest on and are bolted to the pair of large timbers that extends out horizontally from the side of the tower. These platforms have eaves to carry off water, and all of the woodwork named was treated with insulating compounds.

As the four cables are thus mounted they are 20 feet apart in a horizontal direction, this distance having been adopted to avoid any possible trouble from swinging of the cables, which have a sag of 100 feet, as stated above.

The strain of 24,000 pounds on each cable is taken by two strain insulators in series at each end and some distance behind the towers. Each pair of strain insulators is located within an anchor house, and is joined to an iron anchor rod that runs back into a large block of concrete imbedded in the earth. A large glass plate forms the end of each anchor house where the cable enters, and the cable passes through a hole of 9-inch diameter in the center of this plate. Each strain insulator is of rather elaborate design, as it was required to resist a pressure of 60,000 volts and a tension of 24,000 pounds. For greater security against electrical breakdown, however, two insulators were put in series at each end of a cable.

Central in each strain insulator is the steel draw-bar, with an eye in its outer end and a thread, nut and washer at its inner end. The end of the $\frac{7}{8}$-inch steel cable is passed through the eye of the draw-bar, and the strain thus exerted on the bar is resisted by a steel yoke that is attached to the long anchor rod that runs back into the mass of concrete. This yoke consists of a steel bar bent at its middle point so that its two halves are nearly parallel to each other. Each end of this bent bar has a large shoulder, turned inwardly, and against these two shoulders a heavy steel collar fits. The draw-bar to which the cable is secured passes through the center of this collar, and the entire strain of the cable is exerted between the nut and washer on the draw-bar and the steel collar. As the surfaces of the washer and the collar between which the strain comes are parallel to each other, and the pull of the cable operates to draw these surfaces toward each other, the insulation between them is subjected to compression only.

Three pieces of insulation separate the draw-bar to which the cable is connected from the yoke that is attached to the anchor bolt. One of these pieces of insulation is a porcelain tube that flares at one end. This tube is slipped over the draw-bar before the nut is screwed on, and the flaring end of the tube comes next to the eye of the bar where the steel cable is attached. Overlapping the smaller end of this porcelain tube, and extending along the draw-bar to a point beyond the steel collar, is a thick micanite tube or bushing; after this bushing passes through the collar its end turns up into a washer at right angles to the draw-bar. The washer thus formed fits up against one side of the steel collar, and lies between this collar and the large iron washer on the draw-bar.

A micanite cup or flanged washer fits over the end of the iron washer just named, and comes next to the washer formed by the end of the micanite tube. These two micanite washers thus lie between the iron washer on the draw-bar and the collar that is held by the yoke, and are compressed by the entire pull of the steel cable on the draw-bar, that is, by the force of 24,000 pounds. Besides withstanding this compressing force, the two micanite washers insulate the steel cable of the 60,000-volt circuit from the anchor rod that runs into the concrete. The porcelain tube with the flaring end is intended to limit discharge through the air between the draw-bar and the yoke. To prevent surface leakage over the outside edges of the micanite washers, and also discharge through the air between the washer on the draw-bar and the collar

on the yoke, a small, circular copper tank, filled with oil, fits over both the micanite and the iron washers and the nut on the draw-bar.

A sub-station is located near each of the steel towers just described, and conductors from the four cables used in the crossing are carried to each sub-station, and there connected through switches to the regular line wires.

Where a transmission line crosses a highway bridge, it is sometimes possible to carry it on poles set into the framework between the roadway and the sidewalks. This was done on the Scotia Bridge that crosses the Mohawk River at Schenectady, N. Y., where two three-phase, 30,000-volt circuits from Spier Falls enter the city. In this case each wooden pole carrying three cross-arms, intended untimately for twelve wires in four circuits, supports three 1-0 and three 3-0 bare solid copper wires between 25 and 30 feet above the roadway. The bridge is steel, of the truss type, and five or more poles set between the ends of the trusses carry the high-tension lines across.

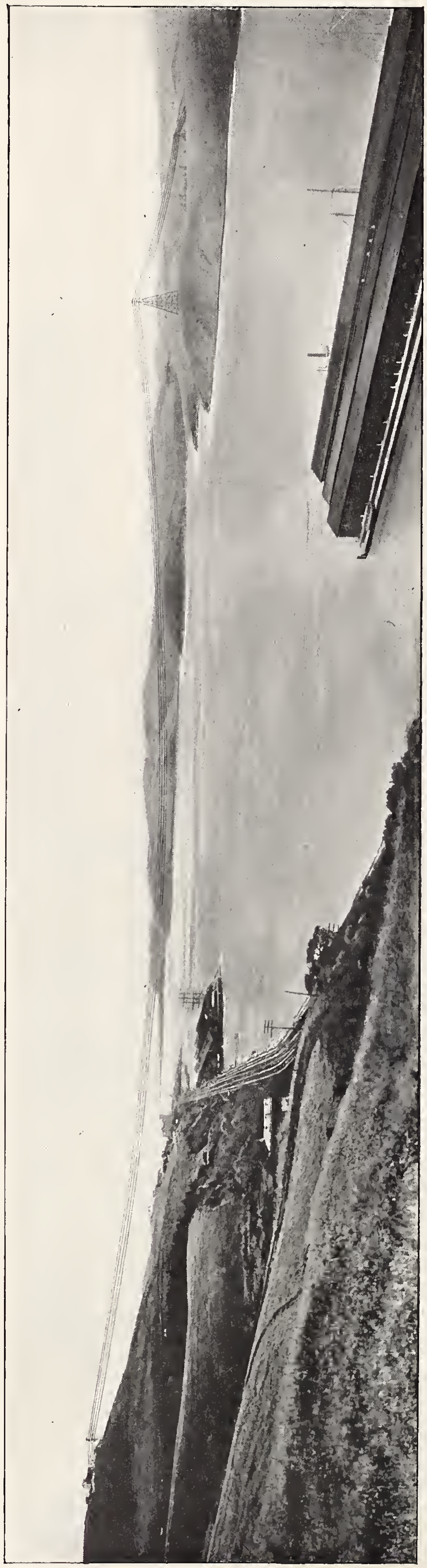
At the Schenectady end of this bridge the direction of the line changes, and the strain of the corner thus formed is taken by a wooden tower. This tower is formed by three poles set in a triangle and not more than 10 feet apart. Cross-arms carrying insulators for the line wires connect these poles near their tops, and diagonal wooden braces are fixed between the poles lower down. The two three-phase circuits just considered run to the General Electric Works in Schenectady, and pass, on the way, over Island Park, the Erie Canal and the New York Central Railway tracks. Large wooden towers, each made up of four corner poles secured to a heavy timber base, connected with a number of lateral braces, and meeting in pairs at the top, are employed to carry the two 30,000-volt circuits just named. Chestnut and Georgia pine timbers treated with "carbolinium avenarius" are used in these towers and the iron plates and bolts that secure the parts of the timbers that are underground are covered with coal tar.

Where the line crosses the Erie Canal each of the wooden towers is 22 feet square at its base, 66.5 feet high from its base to the top of its upper cross-arm, and the two pairs of corner poles are 9 feet apart at the top. Each of the towers carries a cross-arm 17 feet long at the top, and another cross-arm 23 feet long, 4 feet below. Each of the six bare wires on these cross-arms is supported by two insulators set close together.

Where a number of transmission circuits must enter the wall of a generating plant, switch house or sub-station through a row of openings at a common level, it is necessary to erect a special structure a little outside of the wall in order to bring all the wires of the circuits to the required level, so that they may pass through the centers of the several openings.

A structure for this purpose may be formed by two heavy poles set in the earth a few feet from the wall where entry is to be made, and with a pair of long, heavy cross-timbers between them, so that these timbers are parallel to the wall. Each cross-timber should carry an insulator for each wire that is to enter the wall, and should bring all these wires to the level of the horizontal row of the openings in it.

An example showing this sort of construction may be seen at the Saratoga switch house on the 30,000-volt lines between Spier Falls, Schenectady and Albany. This switch house is designed to receive four three-phase circuits, or a total of twelve wires, from Spier Falls, at one end, and to have four similar circuits leave it at the other end. Besides this, two other circuits enter the switch house at one side. A wooden weather shield extends clear across the top part of each of the end walls of the switch house on the outside, and each of these weather shields contains a horizontal row of twelve circular openings each 10 inches in diameter and with their centers 21 inches apart. A few feet outside of each of the two end walls two poles are set with a pair of long, heavy cross-arms, at the same level, between them. Each pair of cross-arms is parallel to the weather shield, and a row of insulators thereon holds the twelve line wires at the level of the centers of the twelve 10-inch openings. A similar construction



CABLES CROSSING THE STRAITS OF CARQUINEZ, CALIFORNIA, USED IN POWER TRANSMISSION BY THE BAY COUNTIES POWER COMPANY. THE DISTANCE BETWEEN THE TOWERS IS 4427 FEET, MAKING THE CABLE SPAN THE LONGEST IN THE WORLD. THE CABLES WERE SUPPLIED BY THE JOHN A. ROEBLING'S SONS COMPANY, OF TRENTON, N. J.

is employed to receive the high-tension lines outside of their entry at the Saratoga sub-station of the same system.

In passing through Redwood, Cal., the 60,000-volt lines, on their way from Electra power house to San Francisco, are carried on insulators supported by long, heavy cross-timbers between pairs of poles. Each of these pairs of poles, where necessary, is braced with wooden struts that extend nearly to their tops. Where this line crosses the river at Redwood, only one tall, steel tower is used instead of two towers,—the more common number in such cases. It was possible to give the wires their required elevation over the river in this case by using a single tower close to one of the banks, because the stream is a narrow one. After leaving the steel tower the line passes by long spans to double structures of the sort just described.

Where a transmission line makes a decided change in direction, it is good practice to locate two or more poles within 5 to 10 feet of each other so that each wire will be supported by several insulators in succession, and will make only a moderate change of direction at each of them. Where the turn made by the line is a right angle, or more, it is well to connect the several poles at the turn with timbers or cross-arms, as this gives a stiff structure to sustain the corner pull, and allows any desired number of insulators to be provided for the support of each wire.

On the 25,000-volt line between Apple River Falls and St. Paul, each right-angle turn is made on a structure composed of five poles, three heavy timbers and seven cross-arms. On the inner side of each right-angle turn two poles are set and united at the top by one of the timbers. On the outer side of the turn three poles are set in a line nearly parallel with that of the two inner poles, and these three outer poles have their tops united by long timbers. The seven cross-arms are laid between the cross-timbers of the outer and inner row of poles. The first and the seventh cross-arm are at right angles to each other in direction, all the cross-arms being radii from a common center. Each wire of the transmission line is secured to an insulator on each cross-arm, and thus has seven points of support in making the right-angle turn.

A rather novel structure is in use on the 33,000-volt line between Santa Ana River and Los Angeles, for switching purposes. On cross-arms near the top of one or more poles a special type of open-air switch, or connection, is attached to the lines, and some feet below on the same pole or poles a platform is built so that an attendant with a good, long stick can mount thereon and make or break connections between the high-voltage circuits above.

6-3

Action of Radium on Aluminium

IN a recent communication to the Russian Physiochemical Society, N. Orloff stated that in April, 1903, he covered an ebonite capsule containing 0.03 grm. of radium bromide with an aluminium plate 0.01 mm. in thickness instead of the mica generally used. In the course of July the author, having opened the capsule, noted on the surface of the aluminium turned towards the radium some protuberances of the same aspect as the surrounding surface of the aluminium and resembling small drops of melted metal. These protuberances proved to be radioactive, producing a photographic image on acting for some minutes through black paper, and even after six months they were found to emit invisible radiations without any appreciable weakening. The author thinks that a stable alloy is formed by the accumulation of material particles given off from the atomic systems of radium around small aluminium nuclei.

Electric Light and Power in Korea

SHOULD Japan defeat Russia in the struggle now going on, and hold Korea, it is thought that the peninsula empire would become one of the most fertile fields in the Far East for electrical development. Certain it is that though called "the land of the morning calm," Korea is not nearly so lethargic as this term would imply. For a number of years it profited by the progressive spirit of its Japanese neighbors, so much so that the first electric light and power plant to be successfully operated in the Orient was started up a few years ago in Seoul, the capital city. It furnishes arc and incandescent lights for the town and operates about 12 miles of overhead trolley railway.

THE TROLLEY LINE ENTERING THE EAST GATE OF SEOUL

According to R. A. McLellan, the chief engineer of the Seoul Electric Company, it was in the autumn of 1898 that the first sod was turned for the building of the first street railway of Korea, and in the early part of May of the following year an official opening took place, a car was run over the road and the success of the enterprise, so far as the construction and operation were concerned, seemed assured. The cars were run by Japanese motormen and native conductors, and for a week all went well. The cars were crowded from morning until night, and for the first time perhaps in the history of Korea the inhabitants of Seoul had some means of enjoying themselves.

At the end of the week, a child, standing one afternoon near the track, was beckoned to by its father. Not

CARRYING MERCHANDISE

thinking of danger, it ran in front of a rapidly moving car and was crushed to death. Instantly the superstition of the people was aroused; the foreign "devils" had introduced something among them from which nothing but ruin would follow; the traditions of their country were disrespected, and the calmness that had been with them for centuries was now visibly disturbed by this innovation. Within a few minutes after the fatal accident, therefore, the cars were attacked, and in a short time two were completely destroyed by fire. A rush was then made toward the power house, with the view of demolishing that structure, for it was conceded by all that it was built on the rain dragon's back, which accounted for the severe drought that prevailed that season. Fortunately, however, they were prevented from carrying out their plans in that direction by the presence of two of the foreign railway officials, and a handful of imperial guards.

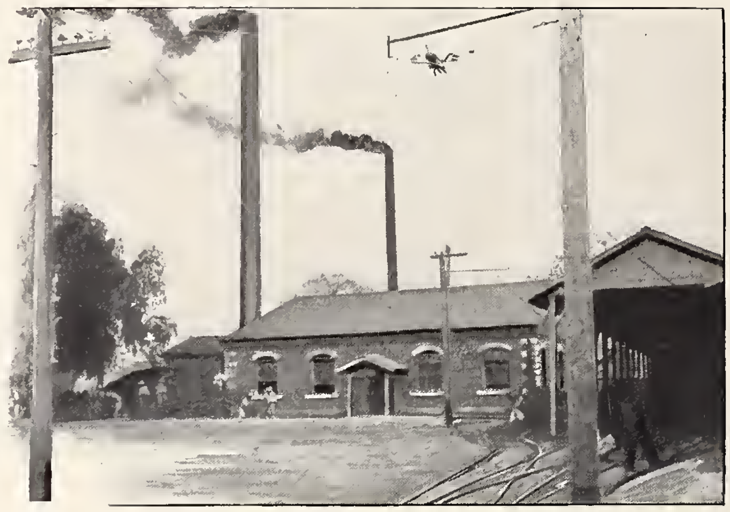
Immediately after this episode the running of the road was discontinued, the management concluding that, for a short time at least, foreigners would have to take entire charge of the plant, in order to insure the success of the enterprise. Late in the summer of 1899, therefore, the road was again put in service with American operatives, and has since continued at work uninterruptedly up to the present time. Accidents have occurred, occasionally followed by slight demonstrations of the people, but the antipathy is slowly giving way and the railway is beginning to be looked upon as a necessity.

The road, when first constructed, was about 6 miles long, and one of the principal reasons for its existence was that it was to carry His Majesty, the king, out to the tomb of the Queen, who was assassinated during the Chinese-Japanese war. This tomb is about 3 miles outside of the east gate of the city. But although a sumptuously appointed car was built expressly for this purpose, His Majesty has never ridden in it. The traditions of the country must be respected, and a plebeian conveyance like a modern street car was not to be thought of as a royal carriage. The machinery first installed consisted of a Babcock & Wilcox boiler of 125 H. P.; a McIntosh & Seymour tandem compound non-condensing engine of 115 H. P.; and a Westinghouse four-pole, 75-kilowatt direct-current generator. This machinery has been running nearly five years, averaging fifteen hours daily, and has given no trouble, notwithstanding that, of necessity, it was left in care of the Koreans several hours each day. The road is now about 9 miles long, with 3′ 6″ gauge, single track and turn-outs at intervals of 3000 feet, the cars being run at intervals of twelve minutes.

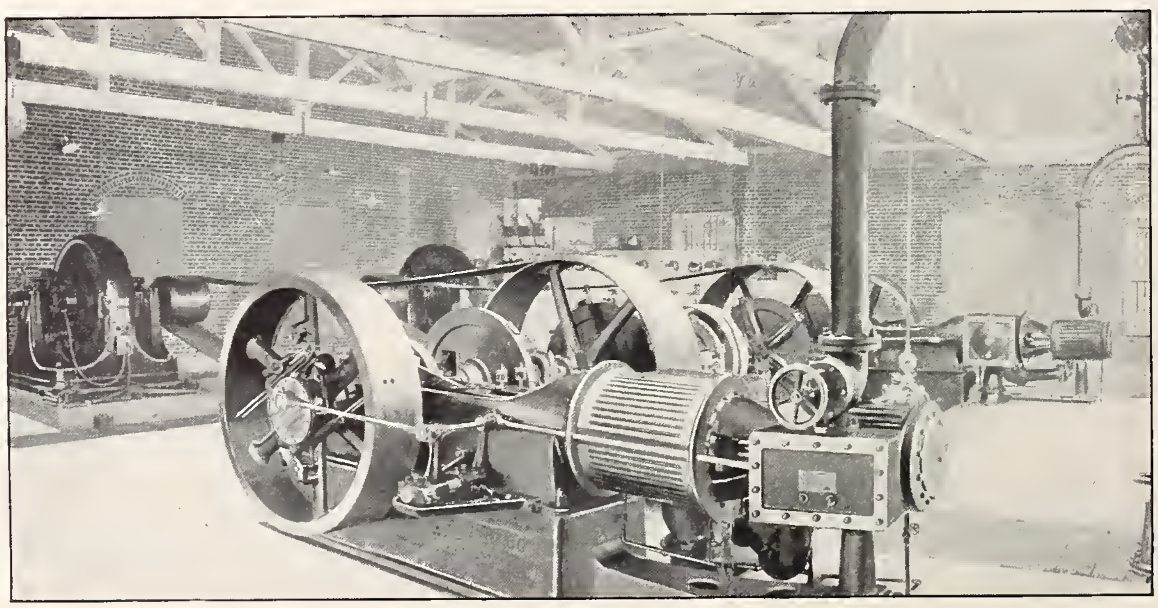
The cars are built at Seoul from plans of American cars, with slight modifications to suit the conditions prevailing at Korea. A closed section in the center accommodates the first-class passengers, while each end is open and has seats running lengthwise. Twelve of these cars run from 7.30 A. M. until 11.20 P. M., and are well patronized by the people, especially in the hot summer evenings, at which time the service is barely sufficient to meet the demands. The generator for a large portion of the time is taxed 25 per cent beyond its rated capacity.

In addition to the passenger cars there are eight or ten freight cars, three of which are constantly in use, hauling coal to the power house, taking away ashes, as well as doing a considerable amount of outside work for the government and private concerns.

Apparently not satisfied with this evidence of material progress, the king concluded that he must have something better than coal oil to light his



THE POWER HOUSE AT SEOUL



THE TANDEM-COMPOUND ENGINES IN THE POWER HOUSE WERE SUPPLIED BY THE BALL ENGINE COMPANY, ERIE, PA.

buildings and palaces, for not a great time elapsed before Messrs. Collbran & Bostwick, the builders of the trolley road, were given a contract for the erection of a light and power plant combined, the first of its kind in the Far East.

Ground was broken for the new power-house in October, 1900, and in August, 1901, one of the officials of the palace opened the throttle of the engine, setting the new machinery in motion and giving light to 2000 incandescent lamps, ranging in candle-power from 16 to 150. Twenty arc lights also flashed upon the grounds and neighborhood. It was a gala night for the people, and, crowded in the power-house and about the adjoining grounds, 10,000 Koreans watched with amazement the wonderful transformation scene, for the foreigners had changed night into day, and what they might do next was a matter of interesting speculation for the natives.

The plant comprises an engine room 60 feet square, and a boiler room measuring 40 x 30 feet, both built substantially of brick. There are two Babcock & Wilcox boilers of 125 H. P. each, while three pumps supply the water, one being specially piped for fire purposes. As the city of Seoul has not, as yet, any water works system, water is procured for the boilers and other purposes from two wells 12 inches in diameter and 20 feet deep, either one being adequate to supply the requisite amount of water.

There are two engines of 200 H. P. each, made by the Ball Engine Company, of Erie, Pa. They are tandem-compound, non-condensing engines, with 13″ by 22″ by 16″ cylinders, and run at 240 revolutions per minute. They are connected by a 6-inch shaft 23 feet long, through the medium of a friction clutch on each end; upon this shaft are mounted four driving wheels, two of 8-ft. diameter and two of 4, the former driving the generators and the latter the exciters. All of these pulleys are loose on the shaft, motion being transmitted to them by friction clutches. This method makes the entire system as nearly interchangeable as possible.

A PASSENGER CAR ON A KOREAN TROLLEY ROAD. THE CLOSED MIDDLE SECTION IS FOR FIRST-CLASS PASSENGERS

Changes have frequently been made from one generator to the other in $1\frac{1}{2}$ minutes. The exciters also are wired in such a manner that they can be run in parallel, or either generator can be excited by either exciter.

The electric machinery consists of two 120-K. W. generators, or, more properly, rotary converters, driven by belt, supplying both direct and alternating current. The direct current, for running the street cars, has a pressure of 550 volts, while the alternating current voltage is 385. This latter current goes to two $62\frac{1}{2}$-K. W. oil-insulated transformers, and being a two-phase current, the three-wire system is adopted to carry it to the different transformers in the city, it having been raised to 2000 volts. It is then lowered to the required 100 volts.

A sub-station, about 3 miles from the power house, contains a 75-K. W. two-phase rotary converter—which is used on a branch line running down to the Han river—a distance of about 5 miles from the main line, to prevent the excessive drop in voltage that would otherwise occur.

Power Measurement with the Electric Factory Drive

An important advantage of the electric drive for factory service, according to E. W. Thomas, in a recent paper before the New England Cotton Manufacturers' Association, is found in the fact that the actual power required by the machinery on any motor may be known at any time, as an automatic recording instrument may be applied to the wiring at the motor itself or at the switchboard in which a continuous record in ink or pencil is transcribed, either upon a circular dial or upon continuous strips of paper.

By these records the variation in the power may be seen at a glance, and the study of these variations and their connection with the different degrees of temperature, the amount of humidity, is most interesting. Oils may be tested on shafting and machinery, and the results of the different makes compared. The tell-tale dial, or strip, shows to the manager another very important feature, and that is whether or not from start to finish of the working forenoon, or afternoon, the machinery on the motor was all in operation the whole of the time.

Records have been obtained where it was shown that when the starting time of a cotton mill was 6.30 in the morning, the full amount of machinery was not running until 7 o'clock, and the same record shows a dropping off in power from 11.30 to 12, showing that the employees were neglecting the work, preparing to leave for the noon hour.

The engineer or electrician may have on his switchboard in the power house wattmeters for each motor, and can at any moment see at a glance whether any motor is running in excess of the normal power required. This is much more satisfactory than the present guess work of trying to obtain the power required for any one room or department, or class of machines from indicator cards from the engine. In such a case one is compelled to run all the shafting in the mill unless cut-off couplings are provided. It is also evident that in case of any accident but a minimum portion of the machinery is stopped.

The practice among motormen of making ordinary stops by reversing as for an emergency stop, is said to have become so common on some trolley lines that one street railway company in New York State has issued a formal notice to its employees as to when emergency stops shall be made.

Some Electric Furnace Processes

By J. WRIGHT

IT would be impossible, within the scope of a magazine article, to deal thoroughly with the many and various industrial processes which have been made possible by the intense heat available in the electric furnace. The writer, therefore, proposes to select the more important of these industries and deal briefly with each in turn, in an endeavor to interest the reader in the advances which have been made in practical electrochemistry and electrometallurgy by the introduction of the commercial electric furnace, first suggested, constructed and exhibited by Sir William Siemens before what was the Society of Telegraph Engineers, in June, 1880.

Some of the leading types of electric furnace construction were described and illustrated in last month's issue of The Electrical Age, and the writer will, therefore, confine himself, in the paragraphs which follow, to a description of the various commercial processes carried out by their aid.

First, and foremost, comes the manufacture of calcium carbide. that chemical combination of calcium and carbon which, when brought into contact with water, gives off acetylene gas. The rapid growth and increasing popularity of acetylene gas lighting has, of course, been responsible for the enormous increase in the number of carbide factories,—an increase which, a year or two back, resulted in a supply of carbide being placed upon the market which was far in excess of the demand, the very natural consequence being that many of the manufacturers had perforce to shut down their plant, or, as an alternative, adapt their existing carbide furnaces to the manufacture of other and more marketable commodities.

Calcium carbide was first manufactured economically, on a commercial scale, by a Canadian, T. L. Willson, in 1888. Although in reality a very simple synthetic process, there are many points connected with the manufacture of calcium carbide on a commercial scale which require more than passing attention, if an economical process and efficient yield be desired. The carbide is produced by heating together in the electric furnace a mixture of 65 per cent. lime (CaO) with 35 per cent. carbon, or coke (C).

A very high temperature,—5972 degrees F.,—is necessary to bring about the combination, in process of which the oxgyen of the lime is liberated and unites with a certain percentage of the carbon present to form carbon monoxide (CO) and dioxide (CO_2) gases. The heat of chemical combination between the carbon and the calcium is, of course, present, but is insufficient in itself to render the mass self-heating. The lime fuses at the temperature of the electric arc and the carbon dissolves in it, forming calcium carbide; and it is instructive to note that the fusing point of the latter combination is actually below the temperature necessary to bring it about, so that the carbide, for some considerable time after its formation in the furnace, remains in a liquid, or semi-liquid, condition.

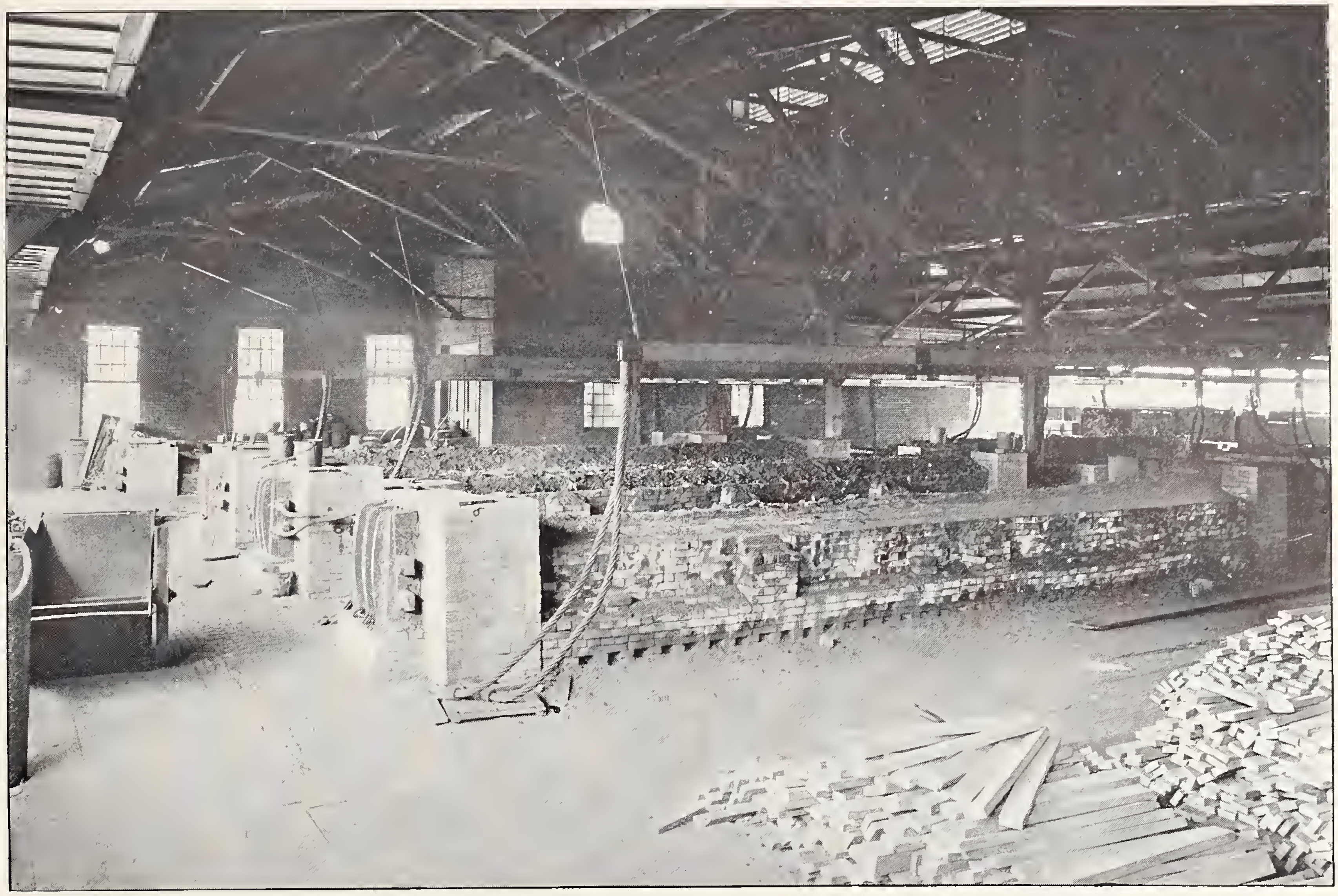
According to Mr. Horace Allen, the author of a statistical article on calcium carbide manufacture, which appeared in the "Electrical Review," of London, for January 5, 1900, the total heat required for the production of one pound of calcium carbide is 6249 British thermal units, which, expressed as electrical energy, are equivalent to 2.464 E. H. P.-hours, or 1.838 K. W. These figures are, in the main, theoretical, being based upon calculations made on known chemical and thermal data. The electromotive force required at the furnace terminals varies from 50 to 60 volts.

The condition in which the raw material should be fed into the furnace has been a matter for considerable controversy. Experience has demonstrated that a carbide furnace works at its best when fed with a raw mixture of coke and lime which has been reduced to granular form, rather than powdered. Extreme comminution of the charge is inadvisable in that, setting aside the principal question of the expense involved in thus reducing the ingredients to a powder, there remains the additional disadvantage that, when thus finely divided, the particles agglomerate around the electrodes, forming a coating which hinders the free escape of tne gases formed in the reaction. In order to eliminate these various drawbacks, the adoption of a mixed charge, in which the particles have been reduced to the size of hazel nuts, is advocated. Statistics have been published from time to time by various authorities which go to prove that, whereas with a finely powdered charge three tons of the raw material are required for the production of one ton of carbide, only 1.7 tons are required in the production of a similar quantity when the charge is of a coarse or granular nature. The theoretical quantity of raw material required for the manufacture of one ton of carbide is 1.44 tons.

Estimates of the total cost of production of a given quantity of calcium carbide vary tremendously, as is only natural, being governed to a considerable extent by local conditions, the cost of power, material and labor. It is impossible in the limited space available to give even a summary of these various estimates; but the following statistics, contributed by Mr. Carl Hering to "L'Eclairage Electrique" in 1899, may be taken as typical:—

According to Mr. Hering, who bases his figures on the results obtained at Meran, in the Austrian Tyrol, it requires, theoretically, 1900 lbs. of lime and 1230 lbs. of carbon to produce one ton of carbide; in actual practice, 2050 lbs. of lime and 1420 lbs. of carbon are necessary. The cost of lime per ton was then about $4, and of carbon $8. One electrode suffices for 10 tons of carbide, and costs $33, or, approximately $3.30 per ton. The electrical energy required per ton of carbide produced was 6400 E. H. P.-hours, which, at $10 per E. H. P.-year, works out at a little above $9 per ton. Accessory machinery, losses, etc., account for about 200 H. P., or $1 per ton, the output being 6.5 tons per day. Labor, at 75 to 80 cents per day, amounts to $3.75 per ton; amortization and general expenses $10 per ton; maintenance of plant, $1.50 per ton. Summing up these various items, we arrive at a total cost of $36.25 per ton of carbide produced.

The manufacture of aluminium is probably the next most important industry involving the employment of electric heat. The apparatus employed, however, does not constitute a furnace pure and simple in the ordinary acceptation of the term, in that electrolytic action enters into the process. But considerable heat is also required to bring about the reduction;



THE ELECTRIC FURNACE ROOM OF THE INTERNATIONAL ACHESON GRAPHITE COMPANY, NIAGARA FALLS, N. Y.

hence the particulars which are here given. There are two well-known processes for the manufacture of aluminium from alumina, which, in the main, bear a striking resemblance to each other. In Hall's process, the alumina, prepared from bauxite, is continuously dissolved in a bath of potassium fluoride. In Heroult's process, the alumina is dissolved in cryolite, a double fluoride of aluminium and sodium. The type of furnace employed, together with the mode of procedure, has already been described in a previous article by the writer, referred to earlier. But the following additional facts concerning it may prove of interest.

The current density employed in the furnace is about 700 amperes per square foot of cathode surface, amounting to about 8000 amperes per furnace. According to Mr. J. W. Swan, the power required in practice is 14 E. H. P.-hours per pound of aluminium. Theoretically the yield should be a third of a pound more; there is, therefore, considerable loss, and room for further improvement in the efficiency of this process.

As already intimated, a necessary preliminary to the manufacture of aluminium is the preparation of alumina from the crude bauxite. A comparatively recent patent (August 14, 1903) taken out by Mr. C. M. Hall, of Niagara Falls, relates to a process for effecting this with the aid of the electric furnace. The bauxite is mixed with a small percentage of carbon and is calcined, after which sufficient carbon is added to bring the total proportion up to from 8 per cent. to 10 per cent. A small quantity of ferric oxide, to enrich the ore, and, in some cases, a flux, such as lime, soda or cryolite, is added, and the whole is intimately mixed with a certain quantity of powdered aluminium. The mixture is then subjected to prolonged fusion in the electric furnace, under which treatment a certain proportion of the added aluminium enters into combination with the iron, silica, and other foreign metals present to form an alloy which sinks to the bottom and is tapped off, leaving pure alumina. The latter is allowed to cool, after which it is pulverized and then subjected to magnetic separation, being then ready for conversion into metallic aluminium in the usual manner.

The manufacture of carborundum, the carbide of silicon (SiC), is probably the simplest electric furnace process. It consists in a direct combination of the two elements, carbon and silicon, under the influence of electric heat, and is carried out in a temporary furnace structure worked on the resistance principle. The furnace itself is loosely built of fire-brick and is dismantled at the end of each run. No cement of any kind is used in its construction, all interstices being left open, in order to provide for the free escape of the gases formed in the process of combination. The furnaces in use at Niagara Falls by the Carborundum Company, who are the sole manufacturers, are 16 feet long, 6½ feet wide, and 5 feet deep. In these the raw material is packed to a height extending about 4 feet above the top of the furnace.

Each furnace consumes 1000 E. H. P. The process of conversion occupies thirty-six hours, and the electromotive force at the furnace terminals is approximately 50 volts. Current is led into the furnaces through the medium of heavy bronze terminal castings, to which the cables are connected; these castings support, inside the furnace chamber, two bundles of carbon rods, to the number of sixty in each bunch. The rods are each 3 inches in diameter and 2 feet long, and, collectively, form an electrical connection between the metal terminals and the furnace charge which is packed around them.

The raw charge consists of 34.2 per cent. coke, 54.2 per cent. sand, 9.9 per

cent. saw-dust, and 1.7 per cent. common salt, its total weight being approximately ten tons. Only about two tons of carbide are produced at each run, as against a theoretical yield of over four tons, from which it will be seen that the efficiency of the process is very low.

During the process carbon monoxide gas is given off, and burns with a blue flame at the various openings. At the conclusion of each run the furnace, as already stated, is pulled to pieces, the charge having first been allowed to cool. The contents are then found to consist roughly of three layers, the outer one being a mixture of volatilized salt, silica, and carbon; the middle one, a mixture of amorphous silicon carbide and uncombined raw material, which is worked up into the next charge; while the center, or layer immediately surrounding the core, is carborundum, about 16 inches thick. The core itself, constituting a bridge between the twe electrodes, is graphite, produced from the original coke under the intense heat.

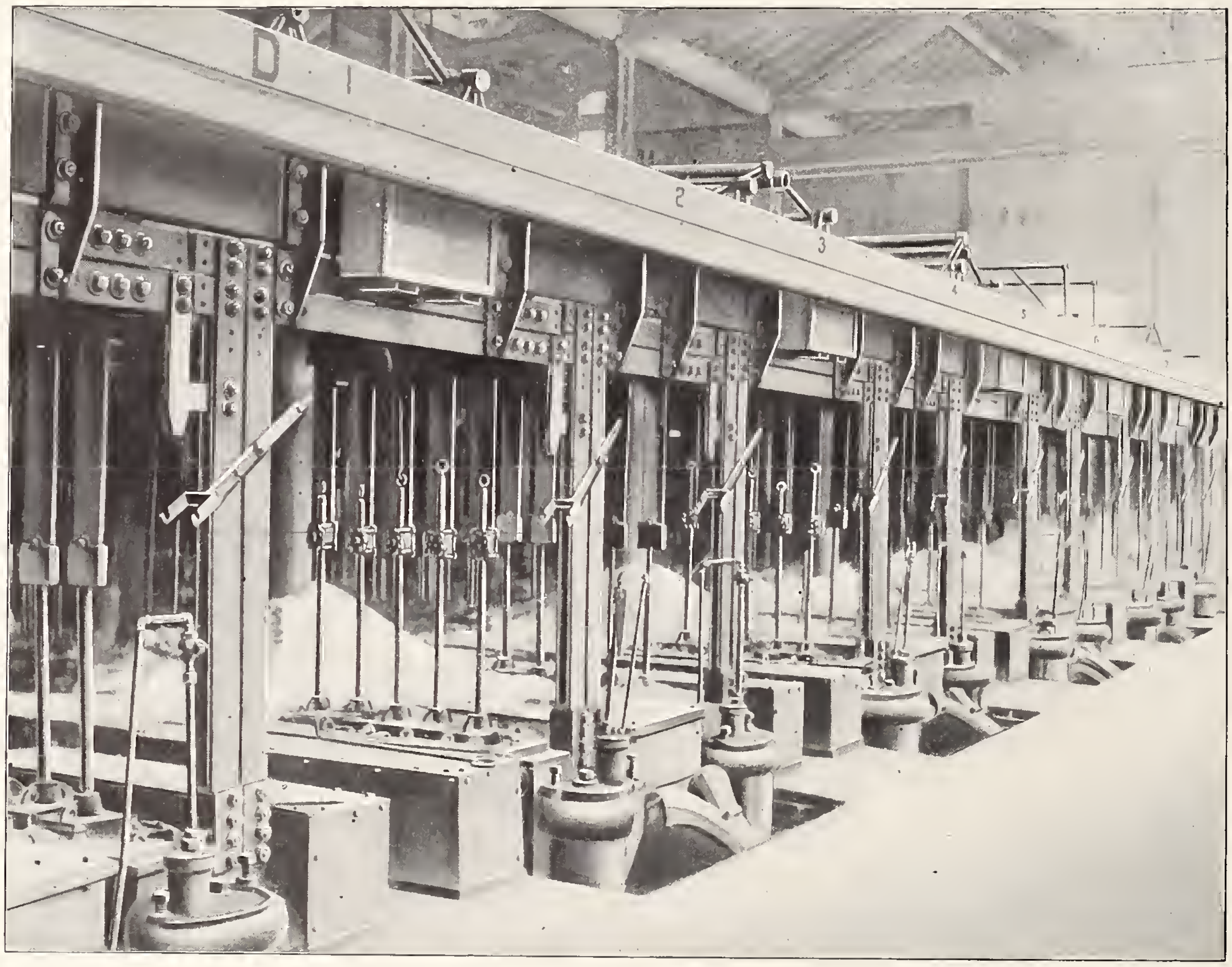
Mr. E. G. Acheson, the inventor of the carborundum process, has utilized this latter feature in a later patent for graphitizing electrodes in the furnace. The form given to the latter by the International Acheson Graphite Company, of Niagara Falls, who work the patents, bears a striking resemblance to that of the carborundum furnace described above.

The process of graphitizing consists in causing the pure carbon, under the influence of heat, to combine with certain impurities which are present in the mass prior to the process. The temperature necessary for the reaction is higher than that required for the decomposition of the carbides formed. The furnace charge may consist of either cylindrical rods or rectangular plates. In the former case, the rods are packed transversely to the direction of current flow, the necessary high resistance path from one to the other being established along the line of contact between the cylindrical surfaces. It is chiefly along these lines that the heat is generated, and this mode of packing the articles to be graphitized results in the production of exterior heat rather than in the mass itself, as would be the case were the articles arranged with their axes parallel to the line of direction of the current. This constitutes the principal feature of the invention, and effects a considerable economy in the current required for the operation of the furnace.

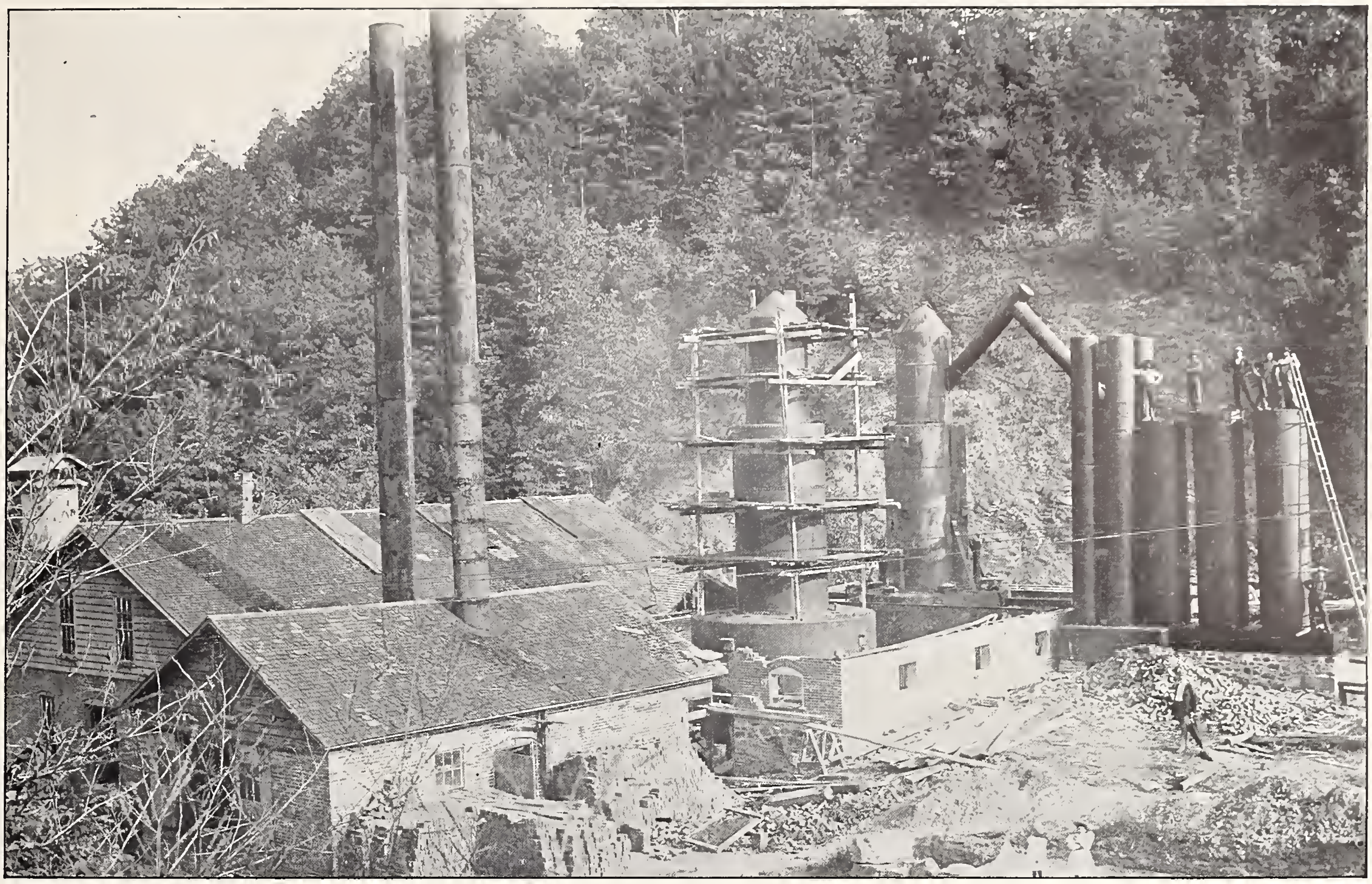
If the objects to be graphitized are rectangular, they are arranged in a series of regular piles along the path of the current, each pile being separated from its neighbor by a filling of pulverized coke. The latter is also employed as a filling around the cylindrical rods in the former case, and between the ends of the charge and the electrodes. The base of the furnace is lined with a refractory layer of carborundum, or similar conducting material, and the whole is covered in at the top with a layer of ground coke and sand.

Carbon, in the form of coke, is largely used as a reducing agent in metallurgical operations, a necessary feature of which is that the carbon, or coke, so used shall be free from impurities, such as silica and the compounds of silicon, which would, if present, combine with the metal under treatment, and result in the reintroduction of like impurities into the finished article. This fact led Mr. C. M. Hall, the patentee of the aluminium process which bears his name, to devise a form of resistance furnace for ridding the coke of these undesirable impurities before it is employed in connection with the extraction of metals.

The process, as patented by him, consists in powdering the coke, and



THE ELECTRIC FURNACES OF THE ACKER PROCESS COMPANY AT NIAGARA FALLS, N. Y., ARE USED IN THE MANUFACTURE OF CAUSTIC SODA. THERE ARE 52 FURNACES, USING 9000 AMPERES OF CURRENT AT 300 VOLTS. AVERAGE VOLTAGE PER FURNACE, 6.4



ELECTRIC FURNACES AT PENN YAN, NEW YORK, FOR THE MANUFACTURE OF BISULPHIDE OF CARBON

mixing it intimately, while thus powdered, with a metallic fluoride, such as sodium fluoride, cryolite, or fluor spar. This mixture, when subjected to heat in a suitable furnace, becomes pure carbon, owing to the reaction set up between the fluoride and the compounds of silicon, which combine to form silica fluoride, the latter being driven off in the form of gas.

By adding a suitable proportion of pitch to the mixture, as a binding material, it can be moulded into electrodes of any desired form, and the purification and baking processes thus carried out in one operation of the furnace. The latter is built of brick and filled with the moulded carbon blocks, packed symmetrically, and insulated from one another by suitable packing. Through the center of the mass, and in close proximity to the blocks, passes a resistance core with end electrodes. An alternating current is supplied to this core by way of the latter, and the heat is adjusted to any desired temperature by varying the current. The actual temperature is necessarily slightly higher than that required for baking alone, in order to produce the requisite thermochemical action for the purification of the carbon.

Carbon bisulphide is another product of the electric resistance furnace, its manufacture being carried out on an extensive scale at Penn Yan, N. Y. The furnace used is illustrated in Fig. 1. It is the invention of Mr. E. R. Taylor, and is the outcome of considerable forethought and experiment. In the original furnaces independent carbon electrodes were utilized as terminals, being protected from a too rapid combustion by broken carbon which was fed into the furnace through orifices immediately surrounding the electrodes. In the latest type of bisulphide furnace the carbon-block terminals have been entirely dispensed with, electrical connection being made directly with the metallic feed hoppers through which the broken carbon is introduced into the furnace.

In brief, the action is as follows:—The upper cylindrical portion is filled with closely packed carbon *C*, through which the sulphur vapors produced by the action of electric heat upon the fused mixtures of carbon and sulphur at the hearth or crucible portion of the furnace CS_2, rise, and, in passing, become converted into carbon bisulphide, which is suitably collected and condensed. Terminal connection with the furnace is secured through the metallic hoppers *MM*, which are four in number, situated at equal distances around the circumference of the hearth, and through which a constant supply of broken carbon is fed. The raw sulphur is made to perform a primary duty before finally entering into chemical combination with the carbon in the furnace to form carbon bisulphide. It is fed in, cold, through hoppers *HH*, which convey it into annular chambers entirely surrounding the furnace body and hearth; in these, the sulphur, while still in a cold state, acts as a heat-conserving jacket, and becomes molten only when it approaches the bottom of the annular chambers which communicate with the furnace hearth, and through which the sulphur feed is effected. It thus reaches the center of activity in a heated condition, and no undue lowering of the general temperature results. By varying the electrical connections to the four terminal hoppers, a very thorough and complete fusion of the carbon and sulphur is effected in the region of the hearth.

The dimensions of these furnaces, as used at Penn Yan, are,—height, 41 feet; diameter, 16 feet. They require a current of 4000 amperes at from 40 to 60 volts to operate them. The regulation is, to a certain extent, automatic; as the temperature, and consequently the degree of fusion, increases, more molten sulphur flows into the bottom of the hearth from the sulphur jackets, and the level of the molten mass rises until it encircles the electrode hoppers and gives rise to an in-

crease in the electrical resistance of the active column, with a consequent decrease in the current, until the working conditions again become normal. Experiments in 1902 showed an output of 10,000 lbs. of carbon bisulphide per furnace in twenty-four hours, but this figure has since been considerably increased.

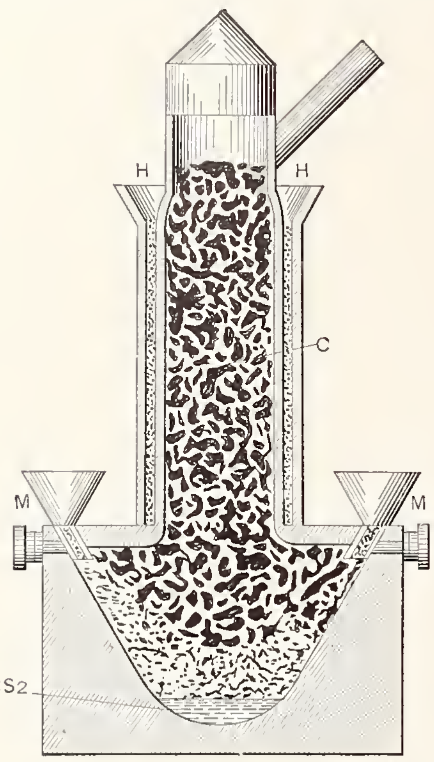


FIG. 1.—A BISULPHIDE OF CARBON FURNACE

Among modern industrial processes which have benefited by the introduction of the electric furnace may be cited the manufacture of calcium and strontium. Here, again, as in the case of aluminium, the processes are partly electrolytic. Calcium, as is well known to the chemist and metallurgist, is of great value in various industries as a reducing agent, the only drawback to its widespread use being its present comparatively high market value, which makes it unavailable for all but experimental purposes, where the question of cost is, within certain limits, no object.

The high price charged for the metal calcium is due to the expensive method of production, which consists in subjecting a dilute solution of calcium chloride to electrolysis in the presence of a mercury cathode; an amalgam of calcium with mercury is thus obtained, from which the mercury is subsequently driven off by heat. Apart from the cost of the process, pure calcium is never produced by this method, a small percentage of metallic mercury being always present in the resultant product.

Messrs. Borchers and Stoekem, recognizing the need for a cheaper and more efficient method of production, turned their attention to the possibilities offered by an electric furnace method, and recently succeeded in designing an electrolytic furnace in which pure, metallic calcium is readily manufactured from its fused chloride.

The fundamental principle involved consists in the employment of a small cathode and correspondingly large anode, between which the fused mass is brought to a red heat, when the metallic calcium makes its appearance around the former as a spongy mass. On removing this latter from the furnace and immersing it in petroleum, a porous residue is obtained, from 50 per cent. to 60 per cent. of which consists of pure calcium. The mass is compressed, or squeezed, while still warm, in order to get rid of the chloride with which it is still saturated, and a product, containing fully 90 per cent. of pure metal, is the result. The latter is then fused in an hermetically sealed chamber, and thereby converted into a firm, silvery mass of metallic calcium. Calcium is claimed to have been produced by this method at a cost of approximately 1s. 6d. per pound, about one five-thousandth of the cost of the original process.

To pass on, however, to a consideration of the furnace employed, let us turn our attention to Fig. 2, which represents a diagrammatic section of the latter. It consists of an outer carbon cylinder *C* built up of several longitudinal sections, each keyed into its neighbor, and the whole held together by a metal ring or band *B*, which at the same time constitutes a terminal connection, the carbon cylinder being the anode.

The upper portion of the cylinder is open, while its lower end is closed by a fire-clay cylinder *c*, surrounding and insulating a metal chamber *A*, which performs the double office of a circulating water tank for cooling purposes, and a support for the cathode *Fe*, which consists of an iron rod placed axially with regard to the cylindrical anode, and screwed, at its base, into the upper portion of the cooling chamber *A*. Inlet and outlet pipes, *i* and *o*, respectively, serve to convey the water to and from the tank, while it is protected from the heat of the furnace by a layer of fluorspar *s*, which, owing to its high melting point, remains solid during the operation of the furnace. The mass of calcium chloride, $CaCl_2$, is placed above this, the action of the furnace being started by several thin carbon rods, placed radially, like the spokes of a wheel, between the iron cathode *Fe* and the inner surface of the carbon cylinder. The heat set up by the flow of current through these rods serves to start the fusion of the upper layer of chloride, and they are subsequently removed, leaving the process of electrolysis to continue through the initially fused mass. The position taken up by the resultant spongy calcium is indicated in the figure by *Ca*.

The apparatus for the manufacture of strontium is, with some slight modifications, incidental to the properties of the separated metal itself, similar to that detailed here for the production of calcium. Unlike the latter, strontium separates out from its compounds in the form of small, spherical masses, which tend to rise to the surface of the molten salt and there again enter into chemical combination with the chlorine from which they have just been liberated.

To obviate this drawback, the iron cathode is made shorter, so that its upper extremity reaches only to a point just above the lower edge of the cylindrical carbon anode. The latter rests upon a circular fireproof structure of insulating material, such as fire-clay, which, in turn, is supported in a cup-shaped depression in the upper portion of the cooling chamber. Unlike the former case, the cooling chamber itself is, in the strontium furnace, given a larger diameter than the carbon anode, and it is in the central depression or basin around which the anode rests that the metallic strontium collects during the action of the furnace, and is solidified by the cooling effect of the circulating water.

Another partially electrolytic furnace process is that exploited by the Acker Process Company, at Niagara Falls, in the manufacture of caustic soda from fused electrolytes. The Acker electrolytic furnace is shown in section in Fig. 3. It consists essentially of a rectangular trough-like structure or hearth *F*, having a steel base *s*, refractory side walls *m* of magnesia, and a removable horizontal false bottom, or dividing partition *p*, also of steel. A flue *f* provides for

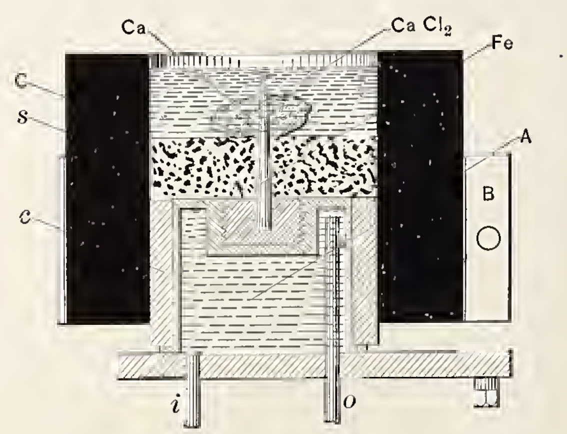


FIG. 2.—MAKING METALLIC CALCIUM

the escape of the chlorine gas evolved during the process, which may be utilized for the manufacture of bleaching powder, while one end of the structure slopes to a well *W* fitted with an injector *A* for the introduction of steam under pressure. The catho-

dic, or negative electrode, connection with the source of current is made through a metal tube *T*, communicating with the well *W*. The anodes *CC* are cylindrical graphite rods, projecting vertically through the cover to within a short distance of the steel partition *p*. *NaCl* is a mass of the raw material sodium chloride, or common salt, which is packed on the top of the furnace, and performs a triple duty, viz., that of conserving the heat generated, hermetically sealing all except the legitimate gas outlets, and providing a source of supply as the charge becomes exhausted. *Pb* is a mass of molten lead extending upwards to a level slightly above that of the false bottom or partition *p*, and in electrical connection with the cathode.

The process of operation is as follows:—Steam being admitted to the injector through the inlet pipe *i*, carries up with it, from the base of the injector well, a mixture of lead, caustic soda, and hydrogen gas, the resultant products of the electrolytic process going on in *F*. On reaching the upper chamber above the well *W*, these three constituent products part company, the alloy flowing back over an inclined partition into the main furnace *F*, while the caustic liquid passes over into the receiver *R*. Hydrogen gas is available at the outlet *o*, and may be utilized for a variety of purposes, chief among which may be mentioned its application to an oxy-hydrogen burner, or burners, for the preliminary fusion of the charge.

The following facts in connection with the Acker process, as carried on at Niagara Falls, were given by the inventor in a paper read by him before the American Electrochemical Society at Philadelphia in 1902:—Each furnace has four anodes, and consumes a total current of 9000 amperes, or 2250 amperes to each anode, representing a current density of about 3100 amperes per square foot.

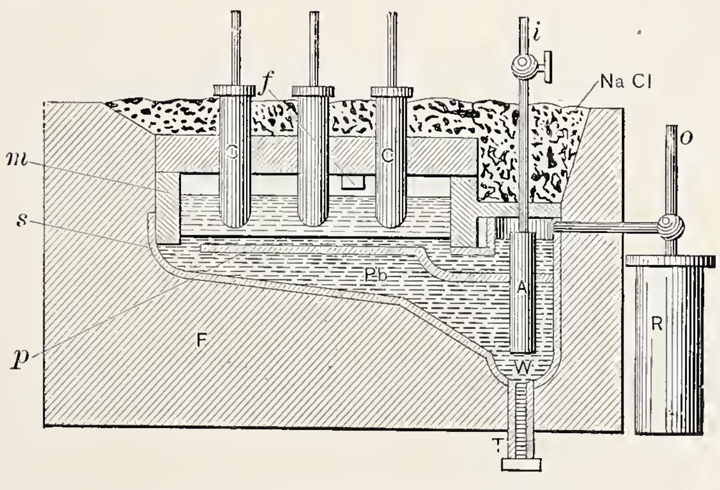


FIG. 3.—THE ACKER FURNACE FOR CAUSTIC SODA

The efficiency of the process is 100 per cent., and the works have been in continuous operation since 1900, with but few temporary accidental interruptions. The anodes do not wear away in use, and the only trouble experienced is said to have been in the electrode connections at the carbon-copper junction, the metal being gradually corroded or eaten away. An improved method of construction has minimized this drawback.

The Darling electrolytic furnace process, which is employed in the manufacture of nitric acid and metallic sodium from nitrate of soda, is comparatively simple. The anode consists of an outer iron vessel, within which are placed two concentric cylinders of perforated iron. A shunt connection between these latter and the outer iron anode protects them from injury during the action of the furnace, while the space between the two perforated walls is filled in with magnesia. The fused salt is contained within the inner of the two cylinders, the cathode, a carbon rod, being immersed in it. Nitric acid gas is set free in the outer space between the walls of the anode and the concentric cylinders, and is conveyed by an outlet pipe to condensing apparatus, where it is converted into the liquid acid. The sodium, on the other hand, rises to the surface of the fused salt contained within the inner perforated cylinder, whence it is removed at intervals by means of a ladle, and placed in tin vessels containing a small quantity of paraffin, which effectually protects it from the action of the atmosphere. The fall of potential between the terminals of each furnace while the operation is in progress is 15 volts.

The process patented in 1901 by Alfred H. Cowles for the manufacture of aluminium-bronze in the electric furnace, though far from efficient, presents several novel points. The furnace consists of a porous carbon crucible, hermetically sealed by a close-fitting lid, through which passes a carbon rod. This latter and the crucible itself constitute the two electrodes. Volatile products resulting from the reduction in the crucible pass through the porous walls of the latter, under pressure of the gases produced in the reaction, and are condensed on the inner walls of a cooling tank or water-jacket, which surrounds the crucible, and, with it, forms an annular space in which the volatile product is collected. In order to prevent clogging of the pores in the walls of the crucible a very high temperature is necessary.

Phosphorus is another comparatively recent product of the electric furnace. The form of construction designed by Messrs. Readman and Parker for this purpose has already been dealt with in a previous article;

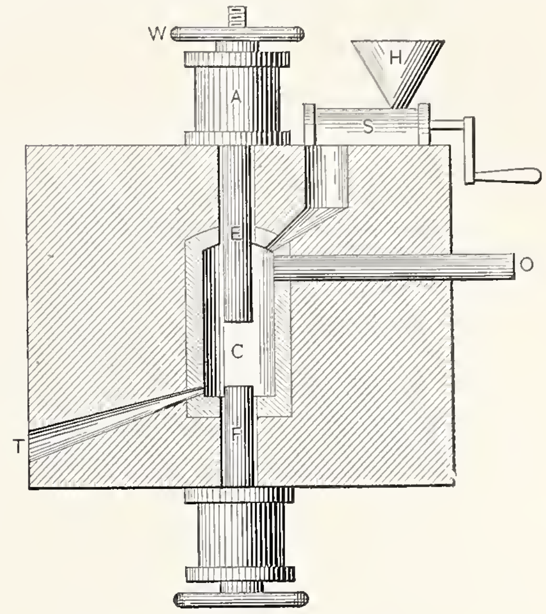


FIG. 4.—THE MACHALSKE FURNACE FOR MAKING PHOSPHORUS

it is employed at Niagara Falls and at Oldbury, England, by Messrs. Albright and Wilson. It was patented in Great Britain in 1888, and consists, briefly, in heating, by means of a resistance furnace in which the charge itself constitutes the resistance column, an intimate mixture of phosphates and carbon, together with a suitable flux, the terminal electrodes being of carbon. The capacity of the furnaces is $1\frac{1}{2}$ cwt. of phosphorus per furnace per day. The process is fairly economical, in that from 80 to 90 per cent. of the phosphorus contained in the charge is recovered. In 1898 the Oldbury works utilized 700 H. P. and the Niagara works 300 H. P. in the manufacture of this element, but the plant and output have since been considerably increased.

Similar plants are in existence in Geneva, Switzerland, and Greisheim, Germany, in which latter country the refusal of patent rights has left the electric furnace method open to all comers.

The Machalske electric furnace process for the manufacture of phosphorus, invented by Dr. F. J. Machalske, of Long Island City, N. Y., and exploited by the Anglo-American Chemical Company, is illustrated in Fig. 4. The furnace consists of a central chamber or crucible *C*, 36 inches by 12 inches by 18 inches, built up of carbon blocks, and lined internally with calcined magnesia and a special mixture, while outside it is jacketed with fire-clay, red brick and a mixture of borax and asbestos flour. The upper electrode *E* is mounted in a special

holder or clamp A, and provided with a hand-wheel and worm W for feed adjustment. It is 4 inches in diameter and 8 feet long. The lower electrode F passes vertically up through the floor of the furnace, and is also provided with a screw and hand-wheel adjustment, as shown. The raw material, or phosphate, is placed in the hopper H, and is fed into the furnace chamber by the screw conveyor S. Once the action is started, the arc can be drawn out to as great a length as 15 inches. An alternating current is employed, with a voltage ranging from 30 to 120 volts. Each furnace takes from 1000 to 4000 amperes, and a temperature of 7000 degrees F. is available within five minutes of switching on.

A molten slag, consisting mainly of calcium silicate, is produced and is run off at the tap hole T, while the phosphorus is driven off as vapor, and passes, by way of the outlet O, into suitable condensers, where it solidifies in the form of dark yellow shavings. These are subsequently treated with sodium hypo-bromide, whereby the red phosphorus is converted into yellow and impurities are eliminated.

In the Machalske furnaces, as described above, 150 lbs. of the raw phosphate can be treated in a quarter of an hour, yielding yellow phosphorus at about 7 cents per pound, reckoned on a basis of 4 cents per K. W.-hour. Two of these furnaces, each consuming 2000 amperes, are in use by the Anglo-American Chemical Company for the manufacture of yellow and red phosphorus.

One of the more recent applications of the electric furnace is in the manufacture of glass, a process which entails considerable expenditure of heat and a comparatively clean source for the latter, such that no impurities in the shape of combustion products shall enter into the fused mass and destroy the purity and transparency of the finished article. Nernst's discoveries in connection with earths that become electric conductors when heated to a certain degree have an important bearing on the development of this industry, in that glass itself may be numbered among those substances; molten glass is, in point of fact, an electrolyte, and thus lends itself readily to electric furnace methods of manufacture.

One of the earliest electric furnaces for glass production was patented in Germany in 1882 by Messrs. S. Reich & Co. It was of the resistance type, and consisted essentially of a carbon crucible, open at the base, and lined internally with a net or bag of platinum wire. The raw material was fed into this, and having been fused by the heat developed in the carbon walls, dripped through into refining vessels placed underneath.

The furnace invented by August Voelker, of Ehrenfeld, is represented in Fig. 5, and is a combination of the arc and resistance principles of elec-

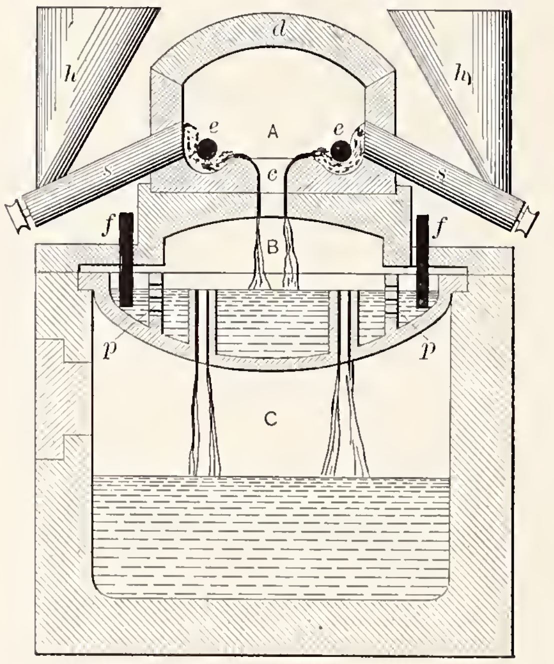


FIG. 5.—THE VOELKER ELECTRIC GLASS FURNACE

tric heating, the upper portion A being utilized as an arc furnace for melting the raw materials, and the intermediate B as a resistance furnace for a species of refining process which the molten mass subsequently undergoes before it finally overflows into the lower receptacle, or trough C.

The arc furnace A is constructed of refractory material, and has a dome d which reflects the heat of the arc set up between the two electrodes e e on to the raw material, which is fed by screw conveyors s s from the hoppers h h, and delivered, as shown, just beneath the electrodes. The mass, having been fused by the reflected heat

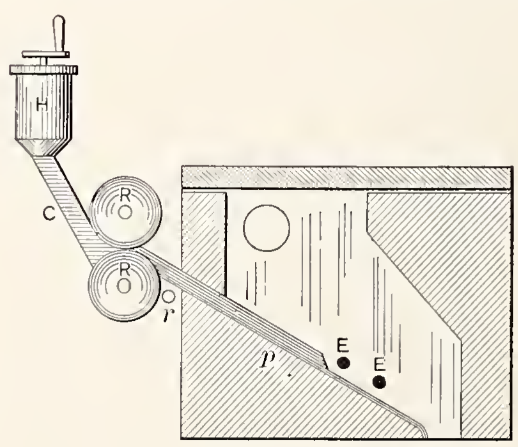


FIG. 6.—THE BRONN ELECTRIC GLASS FURNACE

of the arc, flows down the central opening or chimney c into the intermediate resistance furnace B, which is subdivided by the vertical perforated partitions p p into one central and two outer chambers. In these latter are placed the two electrodes f f of the resistance furnace, the circuit between them being completed by the molten glass. The object of the partition is to prevent contamination of the fluid mass by particles which might become detached from f f.

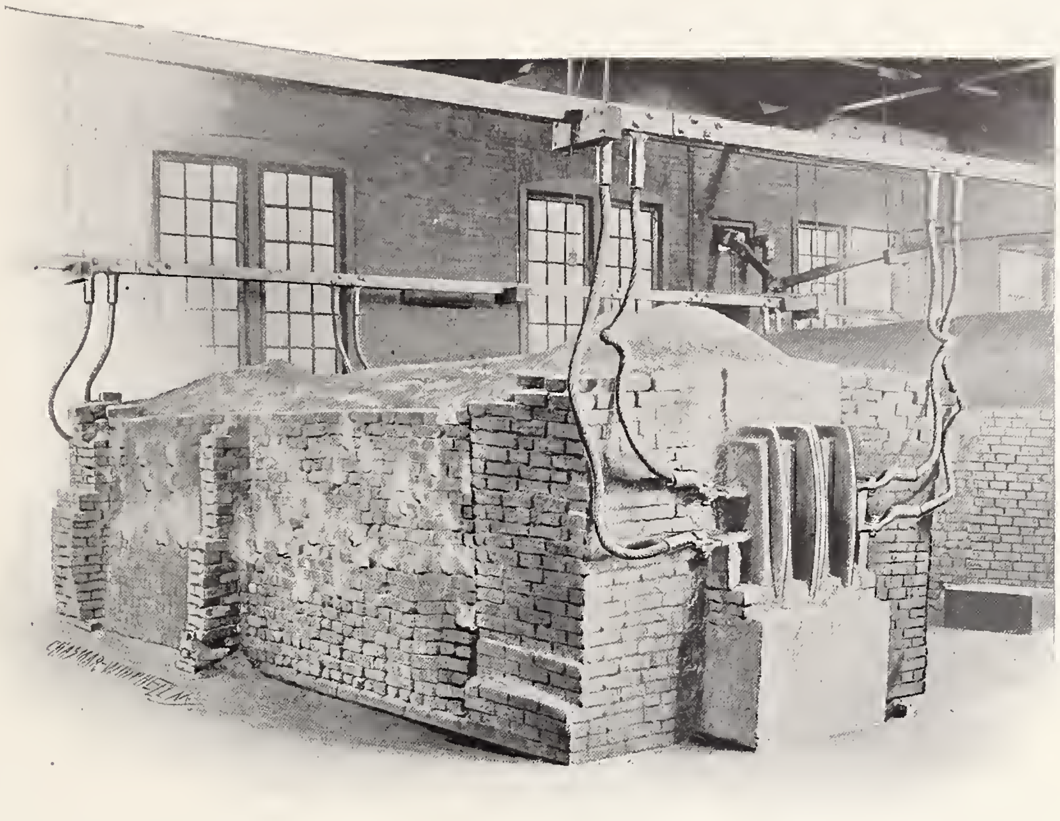
In this intermediate chamber the glass becomes more fluid, and the bubbles of air and gas, carried over by it from the first fusion in A, are driven off. It then overflows into the cavity C, whence it is drawn off as pure glass, and is ready for use as such.

A glass-making arc furnace invented by Albert A. Shade, of Chicago, consists of an inclined tubular hearth, running through a fire-brick support or base, and provided at its upper and lower extremities, respectively, with the usual hopper and screw conveyor for feeding the raw material, and a tapping orifice for drawing off the molten product. Disposed axially throughout the length of the tube are several pairs of electrodes, between which the necessary heat is developed. A preliminary heating of the charge is accomplished by the aid of several gas burners in the upper portion of the furnace, while a series of magnets and iron shields, fixed in recesses provided for them in the hearth, serve to direct the various arcs downward on to the charge as it passes through.

The Bronn process for the manufacture of glass in the electric furnace has been devised with a view to overcoming several of the drawbacks incidental to a continuous process, chief among which may be mentioned the splitting up of the continuous charge, while passing through the furnace, into unequal masses, and a consequent lack of homogeneity in the manufactured product; contamination of the molten glass by particles detached from the electrodes, etc.

The general principles of construction and operation of the Bronn furnace, invented by J. Bronn, of Köln, Germany, are presented in Fig. 6, in which H is a hopper, in which the raw material, in the form of a powder, is mixed with a suitable binding substance, such as water-glass, hydraulic lime, or plaster, which will not affect the transparency or purity of the resultant glass. The mixture is fed down the chute C to the rollers R R, between which it passes, and is thereby transformed into a continuous and homogeneous sheet or rod, as the case may be, the particles being held together by the water-glass or lime before mentioned. It next passes over a heated roll r, which drives off all moisture, and finally emerges on the upper extremity of an inclined plane p, forming the hearth or floor of the furnace. Down this it travels at a

regular rate, dependent upon the speed of fusion and consequent glass formation, passing for that purpose under the arcs playing between the electrodes *E E*, or, if in rod form, traveling down the hearth in like manner between opposite pairs of arc electrodes.



A CARBORUNDUM FURNACE AT THE WORKS OF THE CARBORUNDUM COMPANY AT NIAGARA FALLS

F. A. Becker's method of glass manufacture in the electric furnace calls for the use of three arcs, arranged one below the other, to form a series of steps. The first two arcs consume 100 amperes, and effect the necessary fusion of the raw materials, while the third, situated at the lowest point, takes 50 amperes, and serves to maintain the fluidity of the molten glass. The voltage employed is 40, and the current, owing to the fact that a direct or uni-directional flow decomposes molten glass, is alternating in character.

Last, but by no means least, of the many industrial applications of the electric furnace, only a few of the principal ones of which have been included here, is the smelting, or reduction of metalliferous ores, and the manufacture of steel. As typical of the former, the reduction of arsenic ores may be cited. The importance of arsenic as a marketable commodity may be gauged from the facts that the total output for 1900 was 7300 metric tons, produced by Great Britain, Germany, Italy, Spain, and Canada, the two first-named being the principal manufacturers. The demand is said to be quite equal to the supply, so that there is little doubt as to the need for this useful metal.

Unfortunately, the ordinary metallurgical processes for its extraction from the various arsenic-bearing ores possess many attendant disadvantages, not the least of which arise out of the poisonous nature of the fumes given off during the process and their deleterious effect on the surrounding animal and vegetable kingdom. This is all the more unfortunate in that many of the well-known arsenic-bearing ores are also rich in gold and other precious metals. An improved process, therefore, calculated to increase the output and efficiency of extraction, would doubtless be welcomed by metallurgists all over the world.

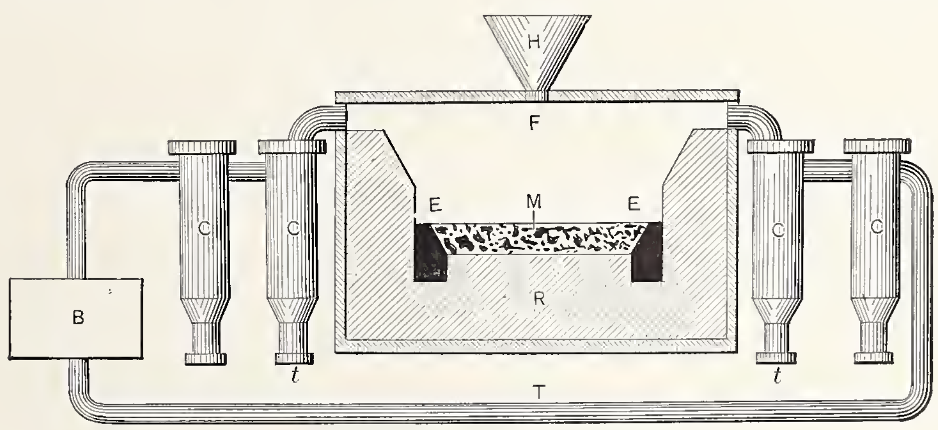


FIG. 7.—THE WESTMAN FURNACE FOR TREATING ARSENIC ORES

Such a process, applicable to at least one rich grade of arsenic ore, has been invented by Mr. G. M. Westman, of New York. It comprises, in effect, a resistance furnace process, and the ores capable of treatment by it are known as "mispickel," or arsenopyrite ores, which also contain ores of gold, silver, and other metals of value. They are very rich in arsenic, averaging 46 per cent. by weight of that metal, which exists in the form of sulpho-arsenide of iron ($FeS_2 + FeAs_2$).

The process of reduction consist in heating the ore electrically in a closed furnace from which atmospheric oxygen is hermetically excluded. The iron combines with the sulphur, forming ferric and ferrous sulphides, which are thrown down in the form of a fused matte, and include the precious metals, while the arsenic itself is liberated as a heavy metallic vapor and is collected in suitable condensers as a fine metallic power. The process is carried on in a circulating atmosphere of nitrogen gas, formed in the first place from the atmosphere by extracting the oxygen by combination with a small quantity of arsenic vapor to form the oxide. Once produced in this manner, the same volume of nitrogen is, by circulation, used repeatedly in the furnace.

The general construction of the latter is shown in Fig. 7, in which *F* is the furnace proper, with a refractory hearth or lining *R* of fire brick. In this are embedded the two cast-iron electrodes *EE*. A central hopper *H* serves for the introduction of the ore, but, at the same time, prevents ingress of air; *M* is the mass of fused ore, which constitutes the resistance path between the electrodes; *C C C C* are condensers, with bottom traps *t t*, in which the powered arsenic collects and from which it is removed. The tube *T* completes the circulatory system for the nitrogen gas, which is kept in motion by a mechanically-driven blower *B*. This latter is reversible, so that when one set of condensers becomes heated the current of gas may be reversed, and the heat energy thus stored up utilized for maintaining the general temperature of the furnace, which would otherwise tend to fall.

An exhaustive test was conducted on an experimental furnace of this type by Mr. Carl Hering several years ago. The process, owing to the small size of furnace employed, was naturally

wasteful of energy; but, by measurement of some losses and computation of others, a fair estimate of the probable cost of reduction in a larger furnace was arrived at. An alternating current of 8000 to 10,000 amperes, at a periodicity of 120 was used, the electrodes, which, as already stated, were of cast-iron, being about 6 square inches in cross-sectional area and rather long. The losses, amounting to more than half the energy supplied to the furnace, were due to several contributory causes, viz., skin effect, hysteresis, resistance, Foucault or eddy currents and conduction. The losses in leads alone from the secondary of the transformer to the furnace terminals, amounted to 44 K. W., while 9 to 10 K. W. were lost by radiation and conduction.

In one trial 185 pounds of ore were supplied to the furnace in the hour, the power consumed in the conversion being about 105 K. W.; the current varied from 4000 to 8400 amperes, and the voltage from 12 to 22 volts, representing a rate of approximately 1140 K. W. hours per 2000-pound ton of ore. According to Mr. Hering, it is quite safe to assume that in a large, well-designed furnace, the power required in the reduction process would not be more than 1000 K. W.-hours per 2000-pound ton of ore. The theoretical heat energy required has been variously estimated at from 200 to 400 K. W.-hours per ton, which indicates a margin for improvement.

The patent rights in Mr. Westman's process are the property of the Arsenical Ore Reduction Company, of Newark, N. J., who are applying it to the large deposits of ore in what is known as the Big Dan claim in Ontario, recently acquired by them.

Rumor has been rife during the last year or two regarding the Stassano electric furnace process for the production of iron and steel. This consists in brief, in first subjecting the ore to a process from which it emerges in a state of fine subdivision. Lime and Coke, also ground to a fine powder, are then mixed with it in the necessary proportions, and the mixture, aided by a suitable binding material, is moulded into briquettes, in which form it is subjected to heat in specially designed arc furnaces. The process is a continuous one, the resultant metal slag being tapped off at regular intervals. An experimental plant was installed at Cerchi, in Italy, the furnace being about 10 feet high, and calling for an expenditure of 1800 amperes at 50 volts for an output of 66 pounds of metal per hour. In the original experiments with the Stassano process 1 kilogram (2.2 pounds) of manganiterous steel involved the expenditure of 4.08 E. H. P. hours; this figure has, however, since been reduced to 2.7 E. H. P. hours for an equivalent output.

The Gysinge process of electrical steel production, also somewhat largely spoken of, is now carried out on a commercial scale at Gysinge, Sweden. The works occupy the site of the original Gysinge sulphite factory, which was burnt down in 1901. Experimental trials have demonstrated that in a furnace having a capacity of about 400 poundsof raw ore, from 1300 to 1500 pounds of steel can be produced in twenty-four hours. The power is derived from a direct-coupled, turbine-driven generator of 300 H. P., and the new furnace has a capacity of 4000 pounds, with an estimated output of 1500 tons of steel per annum. The finished product is said to be of excellent and uniform quality, but further details regarding the actual process are lacking.

In 1901 a French patent was taken out by the Société Électrométallurgique Française on an arc furnace for the manufacture of all varieties of iron and steel in one operation, by the direct treatment of specific mixtures of iron ore, carbon and such other ingredients as are determined by the nature of the product required.

The furnace construction is very simple, consisting of a refractory structure of crucible provided with a domed cover of loose fire bricks, which can be removed for charing purposes, and through which pass two similar vertical electrodes. These latter do not extend to the bottom of the crucible, but only to a level with the upper tapping hole provided for the removal of the slag formed in the smelting process. The molten metal collects at the bottom of the crucible below the level of, and consequently out of contact with, the electrodes, and is drawn off at a separate tapping hole situated at the lower point of the hearth.

As already intimated, the writer has, in the preceding paragraphs, touched but lightly upon some of the leading industrial applications of the electric furnace. The brief programme thus gone through must not by any means be regarded as representing the entire field of utility covered by the latter. New uses and applications are constantly being found for it, and it has every prospect of increasing popularity in an industrial field far beyond the comparatively limited scope of its rivals.

According to recently published statistics, Great Britain's output of coal in 1903 reached the record figure of 230,323,391 tons.

A Radium Forecast in Fiction

TO the late novelist, Lord Lytton, is attributed the forecast of the discovery of radium. In his marvelous imaginative work, "The Coming Race," in many respects the most remarkable of his writings, the novelist gave an account of the life led by a race of human beings far down in the bowels of the earth. The distinctive feature of the book, in fact the pivot upon which the plot hinges, is the possession by those underground dwellers of a mysterious substance named "vril," and which, as described by Lytton, is, according to Hornblow, writing in "The Critic," identical with radium. Hornblow summarizes the similarities between radium and the substance hatched in the brain of the author as follows:—"(1) Lytton says a small amount of vril could destroy a city as large as London, and that a child could destroy an army by merely pointing at it a staff charged with the substance; science assures us to-day that the power of radium is almost limitless, that two pounds of it could destroy three millions of people, and that one ounce would blow up a battleship. (2) Lytton's subterranean race lighted their streets with vril. Science tells us that radium gives out light and heat without waste or diminution. It is, therefore, only a question of quantity and proper adaptation when the world will use radium for lighting purposes. (3) This wonderful vril of the novelist could, he claimed, cure diseases. Indeed, the race depended wholly on it to restore or invigorate life. Experiments recently made with radium in hospitals demonstrate that it will cure certain forms of disease, such as lopus and other skin diseases. It is also believed that it will cure cancer; on the other hand, if applied differently, it will burn the skin and destroy life. Physicians declare that air rendered radioactive will cure consumption, and that water rendered radioactive will cure stomach troubles." Could then, asks Hornblow, Lytton have been otherwise than inspired when he wrote half a century ago of vril—"It enables the physical organization to re-establish the equilibrium of its natural powers and thereby to cure itself"?

The Philippine exhibit at the St. Louis Fair consists of nearly 100 buildings, occupying 47 acres of woodland, in which are housed about 75,000 catalogued exhibits, as well as 1100 representatives of the different peoples in the Philippine Islands. One very interesting feature of the exhibit will be a Philippine school, with teacher and pupils at work.

Electric Heating

Its Field for Central Stations

By JAMES I. AYER

A Paper read before the National Electric Light Association

ELECTRIC heating is a subject of growing interest to the central station manager, and from the past few years' experience, I can say it is worthy of all the consideration that may be given it. Its development generally has been much slower than any other application of electricity, and the reasons are not far to seek. As far back as fifteen or sixteen years ago, when the electric motor was seeking a foothold and alternating current was grudgingly being given a place in the family of "systems," electric flatirons and electric cooking devices made their appearance.

The earliest work of a substantial character was begun by the Carpenter Electric Heating Company, of Minneapolis, in 1889, and continued through a checkered career for several years. Other companies were numerous and short-lived, as most of them deserved to be. While the earliest products were not all that could be desired, and much crude experimenting was conducted at the expense of the enterprising public, some of the product justified itself in the way of fair performance. Had there been a more general use of current in residences and industrial establishments to make the market worth while, a different history would have been written. Considerably less than ten years ago there were few central stations outside of the largest cities which supplied current in the day time. In such cities the rates were high, with the use of constant potential current limited largely to the most important stores, few residences and fewer industrial enterprises. The isolated plants were small and used entirely for lighting for a few hours a day.

Six or seven years ago the conditions rapidly changed, but prior to this, because of the early numerous failures of electric heating companies and the sad experience of the public with much of their product, electric heating had become as much discredited as had the storage battery earlier. Extraordinary efforts were required to place the storage battery where it rightfully belonged, even several years after its revival abroad pointed the way, so strong was the prejudice of our fraternity due to their faith in tradition.

Electric heating, while not meriting the same consideration, was very seriously retarded in its development by this same prejudice, and after eight years' effort, during which period substantial improvement had made possible such success as has obtained, I can say that the present results would have been achieved much earlier had there been no past.

The future of electric heating is assured and yet it has in it disappointing elements for its advocates who do not rightly comprehend its limitations. In the early days of electric lighting, the salesman confidently asserted that all the speculative dreams of the inventor could be accomplished by anyone who would purchase his particular dynamo and appliances. Electric heating is capable of being misunderstood to a considerable degree. The engineer, without some thought, will wonder how we can successfully heat with electricity the staterooms of an ocean-liner, competing with steam, while deriving power from steam, when we cannot heat an office with current from water-power at $30 per year per horse-power, or by meter at 3 cents per horse-power; yet it is true. If this is a problem to an engineer, how does it appeal to the laymen? It will be found that many things are possible that are not commercially practical, and many that appear so are not, and because of this I want to appeal to central station men to get a grasp of the elements of electric heating, and a knowledge of working conditions, that you may move rapidly and reap the benefits of intelligent aplication of this branch of development.

For residences, in all cases, the rates for lighting are the highest charged for any service. This is of necessity on account of relatively small return for the investment and maintenance cost required to supply a residence as compared with other service; it is important that the customer may increase the usefulness of his supply without materially increasing the cost.

Electric lighting costs more than gas directly, but its many advantages, such as cleanliness, convenience and safety, are gains that are now appreciated as having a cash value. The use of fans and sewing-machine motors is not possible with gas, and the operating expense is slight. By adding more of such elements in the home which gas cannot supply, or only in a crude, imperfect way, your position becomes impregnable, for what your customer can get will be well worth the price, and the cost not high.

There are many convenient electric heaters of small current consumption that are effective in supplying wants that gas cannot meet, or when possible with gas, the contrast is even more marked in their favor than a comparison of the two methods of illumination, and I will mention some of them.

Electric curling iron heaters use 50 watts and are only in service a few minutes at a time. The electric heating pad, or substitute for a hot water bottle, is an invaluable device when required, and uses but 50 watts. Electric flatirons are made for sewing-room use of 200 or 300-watt capacity, and though frequently in commission, the period of operation is short, so that the monthly consumption of current is small. They save many trips to the kitchen for a hot iron to press a seam, a bit of lace and not unfrequently Johnny's trousers.

An electric tea-kettle or stove using 200 watts, or a small cup with heater, will produce afternoon tea for two, heat the baby's milk night or day, heat shaving water and is of much value in the sick room. With two small stoves, a breakfast of eggs, toast and coffee can be prepared on the dining table while you wait, and you will not wait as long as usual.

A chafing dish, of course, is more useful for general cooking in the dining room, and until one has "lived with an electric chafing dish," he does not know its possibilities. These require 200 or 500 watts, according to

AN ELECTRIC KITCHEN OUTFIT

the size, and are cheaper to operate at lighting rates than the alcohol kind. An automatic coffee urn for the breakfast table does its work perfectly in from ten to twenty minutes, using 200 to 400 watts, according to size. For the man of the house, inclined to tinker, an electric soldering iron, using from 100 to 200 watts, is useful, as well as a small glue pot.

All of the above-mentioned articles are usually supplied with lamp socket plugs, and are sold ready to connect. There is nothing in the way of special work required to put them into service; their operation is quickly understood, and most are of such low price as to be easy to introduce. Such articles are the best possible advocates for the more extended use of the electric service in the household, and will do much to make a satisfied customer. The fact that, except the heating-pad, none of the articles are at work for more than from ten to thirty minutes at a time, makes the aggregate for the month but a small addition to the total bill, yet a material gain to the station, for it is added output on existing service wires, and the articles serve as missionaries.

Every residence customer on central station lines should be systematically informed of the advantages of these small items, their introduction should be urged, and a record kept of the purchases. The use of the above leads to a demand for electric cooking appliances for the kitchen, and irons for the laundry.

How does the cost of electric cooking compare with gas? Here we have a burning question. If electricity and gas could be used at equal efficiencies for the various cooking operations, this topic would have been omitted, but fortunately that is not the case. Electric cooking apparatus easily operates at an average efficiency of about 70 per cent., and gas at about 15 per cent. in ordinary practice in domestic kitchens. I am aware that some gas operations show a much higher value and others less, and in the hands of experts better average results may be obtained, but this is equally true of electric apparatus. Jane may turn on the oven of either system half an hour in advance of the time required. She can run the burners under the kettles wide open and waste at a greater rate than by treating the electric heaters in the same manner, for they have a fixed maximum, and it is all heat; but whether gas or electric cooking is reasonable in cost depends much on Jane.

Gas varies in quality. It is credited with having from 600 to 800 heat units per cubic foot, and it depends on the pressure, location, kind and condition of burners as to whether complete combustion occurs to develop all these heat units. Assuming that under average conditions 700 heat units are available for every cubic foot of gas, we have 700,000 heat units for a thousand feet. One thousand heat units equal 0.2909 kilowatt-hours. Allowing a drop of 1 per cent. between meter and heater gives us 0.2938 K. W. H. for 1000 heat units. On a basis of 15 per cent. average efficiency for gas ranges, we have effective 105,000 B. T. U. in each 1000 feet of gas.

Electric heat at an average efficiency of 70 per cent. equals 0.4197 K. W. H. per 1000 effective heat units, and for 105,000 effective there would be required 44.065 K. W. H. to give the same results. To compete with gas at equal rates electricity will have to be sold at 5.67 cents per K. W. H. where gas is at $2.50 per 1000 feet; at 4.54 cents per K. W. H. where gas is at $2 per 1000 feet; at 3.40 cents per K. W. H. where gas is at $1.50 per 1000 feet; at 2.83 cents per K. W. H. where gas is at $1.25 per 1000 feet; at 2.27 cents per K. W. H. where gas is at $1 per 1000 feet.

The above is, I believe, as fair a comparison as can be made where exact comparisons cannot well be secured. The results above quoted have been checked by records made in the same family alternately using gas and

electricity each week for considerable periods in a number of cases, and from a variety of records obtained otherwise. It is assumed that suitable equipments both of electric and gas appliances are used.

It is a fair statement that in a family of four or more, with a suitable equipment and ordinary care, it will require from one to one and a half kilowatt-hours per day per person. Taking the higher value, this at three cents per kilowatt-hour is four and one-half cents per day or $1.35 per month per person, and for a family of four equals eighteen cents per day or $5.40 per month; at five cents per K. W. H. it is seven and one-half cents per day or $2.25 per month per person, and for four, thirty cents per day or $9 per month. If economy is practiced, these amounts, at the respective rates, can be reduced about one-third. Our recorded data show an average of about 20 per cent. less than the highest value quoted.

As far back as 1897, Prof. John P. Jackson, at Philadelphia, using much less efficient apparatus for many operations than is now supplied, recorded carefully all current required for all cooking for a family of six, and the average was 830 watts per day per person.

Prof. Jackson kept accurate account and the operator undoubtedly used greater care than can be expected in general practice, but his apparatus was less effective than that which is available to-day, and it should also be mentioned that the value stated includes that required for the hot water for washing the dishes. It is a fair statement that where care and intelligence are applied, for a family of four the cost need not exceed $4 per month at a three-cent rate, or $6 per month at rate of five cents per K. W. H.

It must be understood that the above costs do not include heating water for the bath or laundry purposes. If they did, we could give even coal a close race at summer rates for current. Indeed, for cooking most meals, electricity at three cents per K. W. H. is close to and sometimes less than the cost for coal if no other use is made of the fire, but here we find the hot water supply is incidentally cared for.

While it is clear that low rates are necessary to popularize electric cooking generally, it is a wide field at higher cost than its competitor, gas, and for the same reasons that gas has had such generous recognition, although it costs more than coal.

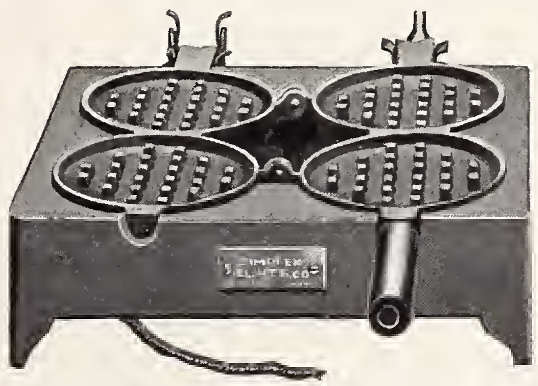
In the households of those whose work is all in the hands of servants, the advantages of electric cooking will not appeal, because economy is not the rule. Existing methods give satisfactory results and the details of method are of no interest. In houses where the work is in the hands of the ignorant "help," there is not a good field to-day, but in the home where the mistress is the cook, entirely, or in part, and in small homes in suburban towns and the smaller cities, the field is wider.

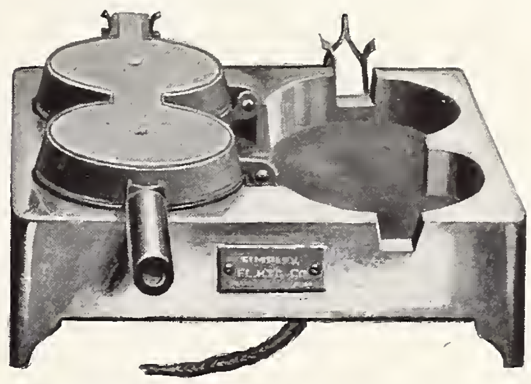
The apartment house kitchen, supplied with hot water from a central source, affords a fine opportunity for electric cooking. The freedom from heat, offensive products of combustion, and leaky valves; the inevitable soot, dirt, and chance explosions incident to gas, and the absence of all cooking devices between periods of use, owing to the portability of electric heaters, are tangible advantages in addition to the more perfect results obtained when you can cook by the clock, not by guess.

In thousands of homes, gas is used as an auxiliary to the coal range, for some of the lighter meals at all seasons, and for much of the general cooking in summer, when the range is not required to be put in commission for other purposes. For all such purposes, electric cooking is not only possible, but more attractive and satisfactory, all things considered, than any other method.

While it may require slightly more instruction at first to get the best results with electric apparatus, because of greater general familiarity with the use of gas for such work, yet after a brief acquaintance the certain results which follow in a given time with the current on, or with a given position of the regulating switch, become known, and the clock is depended on. That this is the ideal method is apparent from a very brief investigation. To simply turn a switch, and have, without flame or any visible effect, the broiler, stove, griddle, waffle-iron, or oven, change its temperature from that of the room to the point necessary for perfect cooking in from two to five minutes, savors of magic.

A variety of cooking devices, each perfectly adapted to its work, entirely independent of one another, separately controlled, having fixed temperature limits so that successive operations may be performed under exactly the same conditions, all operating with no measurable effect on the room temperature, constitute in brief the electrical method. When it is realized that the principal reason for the failure of the cook to reproduce her best results is because the heat supply fluctuates between such wide limits, due to improper care, we can see what opposition we shall meet from the doctors when they realize this personal equation is being eliminated from cooking operations. Exact methods are the only ones that will yield uniform results. Imagine a central station service with the boilers controlled in the manner of the average kitchen range. In arranging electric cooking apparatus, we have departed from the convential form of fuel stove or gas ranges, because electric heat permits of more convenient arrangement, and an electrical outfit can be extended to meet increasing demands without affecting the usefulness or efficiency of the original equipment. A panel board on the wall, with a number of plug switch receptacles and an ordinary kitchen table constitute all the necessary fixtures, the heat devices consisting of ovens, disc-heaters or stoves. Broilers, griddles or the two in combination, waffle irons and water heaters, all of which are light and portable, permit the selection of a more or less elaborate outfit for a family of four, which on occasion may be expanded to meet the requirements of ten times that number without changing the effective value of the first selection. One can start with one or two articles and gradually add to the equipment as may be desired.

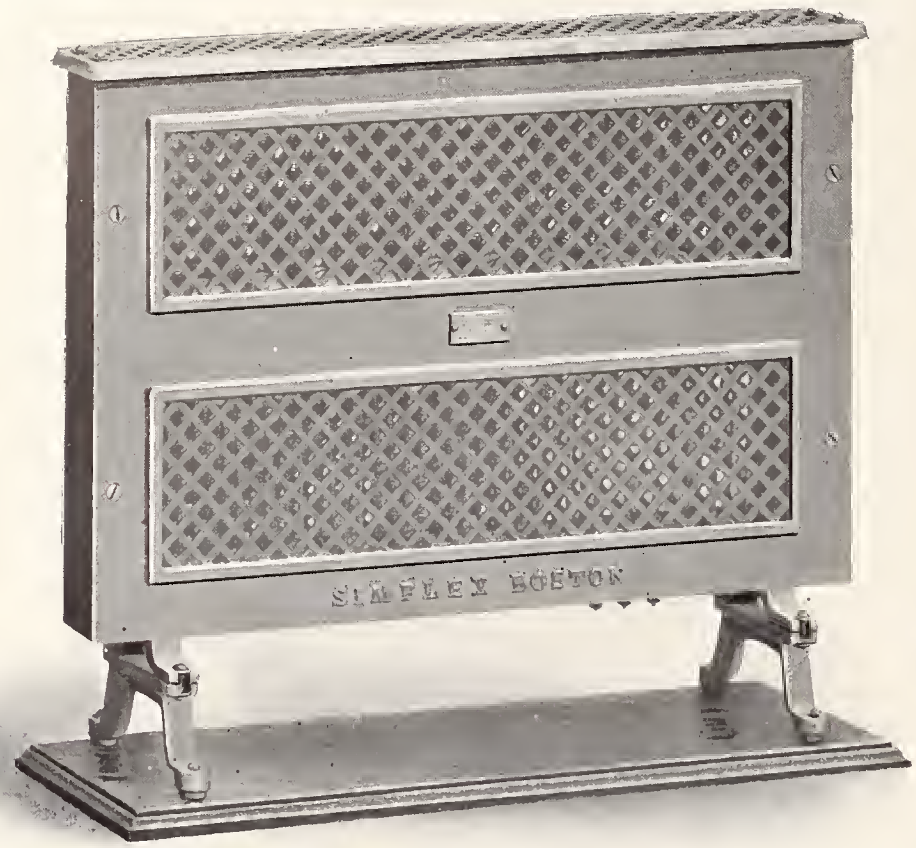




ELECTRICALLY HEATED WAFFLE IRONS

All cooking utensils for the kitchen are preferably made without heaters, so that a variety of different operations may be used on a single heater. More utensils than heaters are always necessay for general cooking, and vessels without heaters are much lighter, more convenient, more easily cleaned and of course cheaper.

In all cases, utensils made specially for electric stoves should be used with them, as they are designed to fit and temporarily become a part of them while in position. Dissatisfaction with disc heaters is the result of operating them with improper vessels. Besides



AN ELECTRIC RADIATOR

the above, there is a demand in residences for electric plate warmers, electric water heaters for bath rooms laundry irons and electric radiators.

Electric plate warmers are usually placed in the pantry and supply a want but imperfectly met heretofore. They are not expensive to operate for those who demand them, and they should be suggested when arrangements are made for installing wires. The large heat capacity for water makes heating it by electric heat in quantity expensive; yet for bath rooms it is becoming more and more in demand. Five gallons of water heated to 190 degrees, when added to ten gallons of water at hydrant temperature in a small bath tub, will provide one with a warm bath, while eight gallons at 190 degrees, added to fifteen gallons at the hydrant temperature, would be more desirable.

The former would require 1750 watt-hours, which at 5 cents per K. W. H. is about 9 cents, and the latter 2800 watt-hours, costing, at the same rate, fourteen cents. This cost is not excessive, but it means heaters of 1750 and 2800 watts capacity, respectively, which must be turned on an hour before the water is needed. If the work is to be done quicker, then correspondingly larger heaters and service wires are necessary. We frequently supply pressure boilers connected to the water-mains containing heaters of smaller capacity, which are arranged with subdivisions of heat; these may be kept on continuously at low heat, and at low rates they are not prohibitive.

Small heaters for washstands that may be connected to the supply pipe are being developed, but for such use a small cup that will quickly heat to the boiling point a pint of water (requiring for this about 850 watts for three minutes) is useful, and current is not so likely to be wasted. The cost of heating water to different temperatures at different rates is here given, which best tells what is required in current supply for a given result in quantity, temperature and time as well.

The equipment of domestic laundries will be found a profitable field. The family requiring but one iron will need a size using about 500 watts, and it will be in demand from five to ten hours per week, according to the size of the family. This means from 2500 to 5000 watt-hours per week. In many families, the larger portion of this work is sent out, leaving even less to be done at home, and of course less weekly use of the iron.

The advantages of the electric iron are conspicuous. The temperature of the room is normal, and that of the iron uniform; it requires no cleaning, no time is wasted going from the stove, and every rub counts. In the house of the man of moderate means, as with electric cooking, it is most used in hot weather, but if encouraged by low rates it becomes a habit. In the homes where one or more servants are regularly employed in the laundry, much attention is paid to its sanitary condition, and there electric irons are rapidly becoming essentials.

Radiators are in demand and are used to advantage, but it is not possible to do usual office or house heating unless current may be obtained at exceptionally low rates. An application that is reasonable is the use of one in a bath room for taking off the chill during the morning bath. For such work a radiator of less than 1500 watt capacity is not to be recommended; one of 2000 watts is better. The latter operating for fifteen to twenty minutes will usually answer requirements, making a total consumption of from 500 to 800 watt-hours. There are other special conditions where they are sometimes used to advantage. Being easily portable, they are valuable about the house for occasional use for short periods.

For electric cooking and electric laundry work in the home, it is clear that special rates, lower than can be made for lighting, be essential to success. The load being principally a summer day load makes special low

INITIAL TEMPERATURE OF WATER, 60 DEGS. F. EFFICIENCY OF APPARATUS, 85 %.

ONE PINT.

	Watts used for				Cost in cents with current at			
Total Temperature, Degs. F.	5 m.	10 m.	20 m.	1 hour.	3 c.	5 c.	10 c.	20 c.
100	164	82	41.04	13.68	.041	.068	.136	.272
150	372	186	93	31	.093	.155	.31	.62
175	468	234	117	39	.117	.195	.39	.78
200	576	288	144	48	.144	.24	.48	.96
212	624	312	156	52	.156	.26	.52	1.04

ONE QUART.

	Watts used for				Cost in cents with current at			
Total Temperature, Degs. F.	5 m.	10 m.	20 m.	1 hour.	3 c.	5 c.	10 c.	20 c.
100	324	162	81	27	.08	.136	.272	.544
150	744	372	186	62	.186	.31	.62	1.24
175	936	468	234	78	.234	.39	.78	1.56
200	1152	576	288	96	.288	.48	.96	1.92
212	1248	624	312	104	.312	.52	1.04	2.08

ONE GALLON.

	Watts used for				Cost in cents with current at			
Total Temperature, Degs. F.	5 m.	10 m.	20 m.	1 hour.	3 c.	5 c.	10 c.	20 c.
100	1296	648	324	108	.32	.544	1.088	2.17
150	2976	1488	744	248	.74	1.24	2.48	4.96
175	3744	1872	936	312	.94	1.56	3.12	6.24
200	4608	2304	1152	384	1.15	1.92	3.84	7.68
212	4992	2496	1248	416	1.25	2.08	4.16	8.32

rates possible and the business desirable.

One method that has been practiced is to install a separate meter, making no restrictions as to the amount to be used, thereby offering all possible encouragement to the customer. Another plan is to use two-rate meters. Rates on either plan, in most communities, may be made with profit as low as five, and in many cases as low as 3 cents per K. W. H. for day service.

Electric laundry and tailors' irons have had the widest use of any single line of electrically heated devices, and to-day offer the broadest single field for development. Being best known, perhaps, of all electric heating devices, it is perhaps worth while to examine them in detail, in relation to the requirements and how well the demands are met.

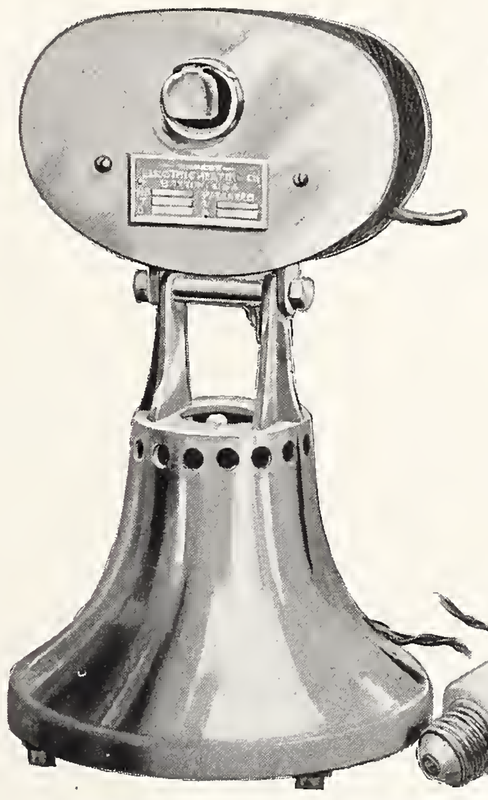
The home needs and how they are met has received attention. Hotel and commercial laundries demand irons for constant and rapid work. In the majority of cases these are heated over gas burners. The rooms are usually small, and when the gas stoves have done their best, it is a place to avoid; yet there we send our linen to be cleaned.

The electric iron, while working, is passed rapidly over damp and frequently wet fabrics with pressure constantly applied. This treatment demands a rapid supply of heat for the work and for the constant loss by radiation, which, though not a large element at the normal working temperature, still is a constant loss.

Irons are made with a given generator capacity for the different classes of work, and if they are continuously employed in the regular manner their temperature is fairly uniform and results are satisfactory. When for any reason the irons are left with the current idle for even five minutes, their temperature rises to about double the normal working value, and according to their construction the generator or winding within the iron goes much higher; in fifteen or twenty minutes the temperature is still higher, which submits the heater to strains that finally become destructive. It is because of this treatment that until improvements were made to enable them to better withstand this treatment, the product was unreliable.

To-day it is still difficult to construct irons for rapid work that will give good service without some arrangement to prevent the overheating when idle. One device which accomplishes this operates automatically to reduce the current supply whenever the iron is placed on its stand, and this incidentally effects a saving of 25 per cent or more during such periods. One other fault incident to overheating, not confined to electric irons, is their liability to burn the garment on which they are first placed when in this condition. Complaint is sometimes made about the breaking of flexible conductors, and this is always a serious fault in improper installations. Cords should be no longer than necessary to permit the free use of the iron. All irons should be provided with a suitable ventilated stand and no other kind.

The advantages of the irons are conspicious; they are also clean; they heat in from four to five minutes; will operate continuously; may be kept at practically uniform temperature under all conditions of service, and when controlled have long life, and in the best products, in common with other types of electric heaters, do not change their resistance with continued service.



FOR LIGHTING CIGARS ELECTRICALLY

The cost for operation per hour varies with the size. For the all-around use for domestic requirements without a regulator, the most efficient use from 500 to 550 watts. The regulators effect a saving in such service of from 15 to 20 per cent.

In laundry work in hotels and commercial laundries, the irons vary in size, and their consumption is from 350 to 600 watts per iron, and the regulators effect fully 20 per cent in saving. In clothing and similar manufacturing establishments, the tailors' irons are larger and require from 600 to 1000 watts per iron; the average is perhaps 750 watts. Except where electric irons are used, gas irons with burners within them, connected to the supply with rubber tubing, are almost invariably used. They have no end of trouble with leaky tubes, which frequently burn off, break or slip off the connection; combustion is more or less imperfect, and they are dirty. All of this makes a bad sanitary condition and a constant source of trouble.

While many use electric irons, the change has barely begun, and the reason is largely due to the failure to secure attractive rates; from 3 to 5 cents per K. W. H. is what is necessary to handle this class of work, which in many cases should demand and secure such rates, for they are (especially the garment factories) customers entitled to the central station's best consideration.

I know of not a single establishment that ever adopted electric irons that changed to other kinds, and I know of several considerable installations that have continued their use for more than twelve years. With this showing, and the present improved product, there is no reason why this branch of electric heating should not develop important additions to central station output.

In commercial laundries, the heating of iron rolls has been done electrically, and in book binderies the electric heating of presses and other machinery has been carried out to a considerable extent.

Some electric cooking can be developed in the use of stoves for the noonday meal for clerks, and when no cooking is desired, a heater or two for warming the lunches and hot water heaters for making tea can frequently be placed.

Book binderies, pattern shops, furniture stores and many other establishments find glue heating expensive, dirty and dangerous with gas. Electric glue pots operate cheaper and are entirely free from all the objectionable features of the others. There are dozens of establishments equipped with twenty or more each, and many hundreds in use in smaller groups. Electric sealing-wax heaters are used by jewelers, banks, express companies and others.

Soldering irons have a considerable field in small shops and some classes of manufacturing. These articles have had limited durability, owing to the necessary high temperature when working effectively. Because of their form they are easily constructed, but not to stand the severe duty. Later improvements in construction and the use of automatic temperature regulators have made them a very satisfactory product. Special rates are not necessary except for considerable installations, as the cost of operation is usually lower than for gas irons.

Hot-water urns for barber-shops and bars, as well as lunch rooms, can

be installed. Doctors' offices and hospitals require sterilizers for instruments.

Manufacturing establishments have many applications of heat to machines where electric heat is frequently applied at a saving in cost. With all applications it is important that a responsible representive gains full knowledge of the apparatus, its workings, the proper methods of installation, and then sees that the customer is clearly instructed in all essentials for its proper care, operation and maintenance. Too much is taken for granted as to the customer's understanding in this respect, which frequently develops unconscious abuse, resulting in annoyance, interruption of service and frequently avoidable expense.

As to the durability of the apparatus, it can be asserted that the general product of experienced manufacturers will give quite satisfactory results if the above remarks as to acquainting customers with what is necessary for fair treatment are duly observed.

Perhaps a statement of performance will give a better answer regarding durability than in any other manner. In the winter of 1902-3, about a year and a half ago, the Natural Food Company of Niagara Falls, N. Y., began the manufacture of a new product they call "Triscuit," it being a cracker of shredded wheat baked or toasted by having heat applied to both sides at the same time. The operation consists of passing the product through a machine between two endless link belts enclosed except at one end. The links of the belts are electric stoves, and are so arranged that the triscuit is fed in and held pressed between the faces of two stoves throughout the complete circuit of the machine. The operation is continuous. Each machine has about 2500 stoves and has a product of 17,500 triscuits an hour. They are operating about 10,000 of these stoves and their failures up to date have been less than 1 per cent. from all causes.* This is the largest development of electric cooking in the world, and is successful in every way, the cost for baking, including labor, being less for the same amount of product of triscuits than for shredded wheat biscuit, using coal.

When the plan was presented, I agreed that we could build successful heaters, and that the cost of operation would be reasonable. Results show that if power was derived from steam the statement would still hold good. There is no practical way of baking by applying heat uniformily on both sides at once under pressure except by electricity, and the method has advantages.

In conclusion, I want to refer to some of my previous statements. In the comparisons I have made, I have not tried to make the best nor the worst possible case, but I have stated results developed in practice which a considerable experience leads me to believe are results you will derive. In giving a basis of costs, I am confident experience will show they are fairly stated.

Central station managers should gain personal knowledge of electric cooking from installations in their own homes, and accept the manufacturer's advice in the selection of the outfit. They should do this also with other articles of domestic use as far as possible.

I have shown that for cooking, especially low rates must be made. That in many cases these rates can be made is a reasonable claim. The load is an added day load, and largely a summer load. It is added in most cases to idle transformers, to idle lines, and to running machinery, which in most cases is likely to be operating at low efficiency. For a considerable additional load, it means in many stations an addition for cost of coal only, and in many instances it will be less for this addition than your present cost per K. W. for this item.

Until electric competition developed, gas companies made no progress with heating. They maintained high rates and limited outputs, never realizing the splendid chance for benefiting themselves and the public until they were literally kicked into it. The stimulant to enterprise is adversity, if you do not get too much of it. Central stations of this country have in most cases experienced years of struggle to reach the satisfactory results finally obtained. With this splendid record, and the substantial results already achieved in the new field, consisting of upwards of a thousand complete electric kitchens, more than fifty thousand smoothing irons, and the many thousand other items which I can vouch for are in practical operation, it needs no prophet to say that central stations will accept the opportunity and get the business.

* Illustrations and additional particulars of this plant appeared in "The Electrical Age" for March, 1904.

Wireless Telephony at St. Louis

AN attraction of especial interest to telephone men visiting the St. Louis Exposition will be demonstration of wireless telephony by means of a searchlight. Advantage has been taken of the peculiar phenomenon that when a telephone circuit is superimposed upon an arc light circuit variations in the telephone circuit cause the arc light to increase or decrease in intensity. By means of a proper reflector, a beam of light is focused upon a selenium cell which is in circuit with a receiver and a battery. The operation is as follows:—Variations in the intensity of the reflected beam of light due to the current at the sending end, tend to increase or decrease the resistance of the selenium cell, which in turn allows a varying current to flow through the receiver, and so duplicate the vibrations of the distant transmitter.

Stealing Telephone Wires in India

ACCORDING to "The Electrical Review," much annoyance and inconvenience to the telephone service have been caused in India by natives who have conceived the idea of stealing several spans of copper wire from the telephone line which establishes communication between Bangalore, Sivasamudram, the Kolar gold fields and intervening stations on the transmission line. The natives have a great liking for copper, since it forms a part of their wearing apparel, as jewelry for the ears, nose, toes and arms.

The police have repeatedly failed to capture the guilty parties; so the ever useful electrical remedy is now being employed. From 6.30 P. M. until 6 A. M. a pressure of about 1000 volts is employed on the line, all telephones being disconnected therefrom. If telephone communication is desired at any point on the line, the operator on duty at the generating station is made aware of the fact by means of a signal lamp, which becomes extinguished by the blowing of a fuse at the latter place. The person desiring to talk, signals the operator at the generating station by short-circuiting the telephone line, thus blowing the fuse and extinguishing the signal lamp. The operator then disconnects the high voltage from the telephone line for the time being. This may seem to be rather a drastic remedy to employ, but it offers the only means of effecting a cure for all time.

Nickel, which until a few years ago was a comparatively rare metal, is now in large demand. It is usually found associated with copper as an ore, and is difficult to separate. The ore is smelted to a nickel-copper matte, from which the nickel was formerly obtained by electro-deposition; but the improvement in purely chemical processes has put a stop to this industry, and electrolytic nickel is no longer on the market.

Electric Railways in the United States

Results of Fifteen Years' Development

By LEMUEL WILLIAM SERRELL, M. E.

IN the early part of 1888 only 86 miles of electric railway were in operation in the United States, using about 172 cars. The census report for June 30, 1902, showed 22,589 miles of electric road, using 67,199 cars, and requiring 1,298,133 H. P. for their operation. The number of passengers carried during the year was nearly 6,000,000,000. The total gross earnings reported were $241,584,697, and the operating expenses were $139,012,004, leaving net earnings of $102,572,693. The total number of employees was 138,183, and the wages paid them amounted to $84,636,275, or an average of about $614 each per annum. The above length of line has now been increased to nearly 26,000 miles.

The original electric cars were usually old horse cars mounted on improved trucks carrying electric motors of about 20 H. P. capacity, having a maximum speed of about 12 miles per hour. To-day we have not only city railways, but interurban railways, operating on private rights of way, carrying passengers, express, and freight matter, equipped with cars that will run a mile a minute, and we find some of the electric roads now putting on sleeping cars nearly 60 feet long, each equipped with 600 H. P. in electric motors, and ten compartments with upper and lower berths that fold up during the day time, and so arranged that the cars can be converted into parlor cars having twenty chairs for the day service.

This wonderful growth in such a short time has created in the minds of the promoter, the banker, the investor, the citizen, and the politician the idea that fortunes are easily made in the construction and operation of electric railways, or such phenomenal results could not have been accomplished. Such results have been a temptation to both the promoter and banker to approve of over-capitalization, and in many cases the investor has already proved the victim. But worse results still have been produced politically.

The uninterested citizen has been led to believe that the municipal councils have been giving away the use of the highway without adequate compensation, and many corrupt politicians have made street railways pay high for the privileges so granted. The voice of the public likewise has compelled the municipal councils to introduce restrictions into the franchises asked for, which have become more and more unfair to the railway companies, until now franchises are so burdened with conditions that the construction of a road has become exceedingly expensive, and the short life of the franchises are not more than sufficient to allow the companies to get well established before the municipalities demand a readjustment of everything regarding compensation.

This rapid development of electric railways is very different from the development of gas and water companies, for we find that the first gas company was built in America in 1816 in the city of Philadelphia, and the development of gas has been quiet and gradual and extending over many years. Gas and water mains are out of sight in the streets, and consequently have not attracted as much attention from municipalities, and the companies have had a fairer chance to live and make a reasonable profit without being burdened with too many onerous restrictions.

It is a very serious question that confronts the investor to determine whether or not it is safe to buy street railway securities. There is no doubt that good street railway securities form the basis of a very safe investment, but over-capitalization has crept in, municipal regulations and conditions have become too severe, the expense of construction has been increased, and in many cases street railway companies have not made proper provision for maintenance of track and equipment. Accidents on street railways are about eight times as frequent as on steam railways, and provision must be made to settle the claims for these out of the earnings.

The report of the Milwaukee Railway & Light Company for 1902 shows 3791 claims of all classes for accidents, of which 658 were settled at a cost of $51,847. This company sets aside 4 per cent. of its gross receipts to establish a reserve fund to pay for accidents, the amount of this reserve fund being about $100,000 per annum.

Labor troubles likewise have crept in until strikes on street railways have become more numerous and dangerous to life and property than has ever been known in steam railway operation, and the settlement of any strike always means a loss to both sides. The strike in Scranton, Pa., several years ago reduced the earnings of the company for the fiscal year nearly $300,000.

It is not the purpose of this article to be pessimistic, but simply to bring forward both the good and bad sides of the situation for calm consideration.

It is to be regretted that outside of the State of Massachusetts inflation and over-capitalization have been too freely indulged in. As an illustration of this point, one of the electric railway systems in Ohio shows that, due to consolidations, in less than four years' time the indebtedness was increased from $24,000 to $44,000 per mile, with corresponding increase in capital stock. Further, the Bureau of Railways of Pennsylvania, in its recent report, draws a comparison between the electric railways in that State and the Pennsylvania Railroad system east of Pittsburg.

The total electric railway mileage is given at 2175 miles, and the total Pennsylvania Railroad mileage at 5787 miles. The total capitalization of electric roads, including operating companies and leased lines, amounts to $100,694,919 funded debt and $180,499,557 capital stock, or a total capital account of $281,194,476. The funded debt of the Pennsylvania Railroad is given as $89,000,000; its capital stock as $203,000,000, or about $290,000,000 total capital account, or about the same as electric roads, while the earnings of the Pennsylvania Railroad in one year were $101,329,795, against $29,001,741 for the electric, or more than three times as great.

Comparative figures have been published covering a period of about

ten years for the States of Pennsylvania and Massachusetts which show that in Pennslyvania the capital stock has increased 500 per cent., debt has increased about 680 per cent., and the gross earnings increased about 170 per cent., while in Massachusetts these figures are 129 per cent., 225 per cent., and 136 per cent., respectively.

It has been argued that electric railways can be operated for a less percentage of their gross receipts than steam railways. This is probably so, as the wear and tear on rails is much greater with locomotives, due to the pounding of the reciprocating parts, than on electric roads. The method of generating power in electric central stations is far more economical than in locomotives, while the substation method of distributing power to the cars has made possible the construction and operation of long-distance lines; but the wear and tear on the cars is probably greater on electric roads than on steam roads, owing to the fact that there are more frequent stoppages and a great amount of electric machinery on each car to keep in repair.

Many interesting comparisons have appeared from time to time giving the earnings of electric railways, as compared with steam railways.

The Interstate Commerce Commission examined into this matter a short time ago, and reported that the average operating expenses of steam roads in the United States are 64.6 per cent. of the gross earnings, while those of interurban electric lines are only 54 per cent. A number of individual cases are likewise cited which give this same ratio for electric lines competing with steam railways, and show that electric roads are operated from 10 to 15 per cent. cheaper than competing steam lines. These figures apply to passenger traffic, while interurban electric roads handling baggage, express matter and freight are reported as handling this for about 21 per cent. of the gross receipts. The average gross receipts for electric roads reporting freight and express earnings are about $650 per mile of track per annum from both of these sources.

It must be remembered, however, that the interurban roads referred to do not run parallel with steam roads for any great distance. Still, in many cases the distance has been sufficiently great and the loss to the steam roads has been sufficiently large to make the latter roads endeavor to recover, through rate wars, the travel they have lost, and the curious consequences of such rate wars have been frequently disastrous to the steam railway through the loss of both passenger and local freight business as well. It must be remembered that the usual rates charged for passengers on steam railways average fully 2 cents per mile, while the rates on the electric road average about 1¼ cents per mile, which means that steam railways must cut their passenger rates in half to meet the normal rates charged by the electric roads, with the advantage in favor of the electric roads as affording the most desirable method of traveling.

The average earnings from passenger travel on steam roads vary greatly, those of the New York, New Haven & Hartford Railroad being probably the greatest, at $10,400 per mile. The New York Central earns about $7000 per mile, the New Jersey Central about $4000 per mile, the Norfolk & Western $1400 per mile, the Illinois Central about $1900 per mile, and the Southern Railway about $1400 per mile. It is, therefore, reasonable to assume that the average passenger earnings of steam railroads throughout the country do not exceed $2500 per mile, as compared with about $3800 on interurban electric roads, some of which latter, however, are reported as being as high as $5500 per mile.

It must be remembered that the electric railway, both city and interurban, has come to stay; its development, however, has been so rapid that a tendency to overbuild has been created. Inflation in its securities has undoubtedly taken place even when the construction has been accomplished at an increased cost. The probabilities are that many railways have not made ample provision for maintenance, and there is no doubt that the high speed with which the cars are operated over highways makes danger from accidents very great.

Where such conditions exist, some reorganizations must necessarily follow, and the history of steam railway reorganizations must repeat itself to some extent with electric roads before they can be put on a permanently sound basis. On the other hand, it must likewise be remembered that electric railways are usually built through territories containing a dense population, that the service is frequent, and that increased opportunities for travel induce a desire to travel. The tendency of the people is to use cheap methods of transportation, both for business and pleasure, and to this extent electric railways are the means of increasing both business and social intercourse.

Further, electric railways can probably be operated as cheaply, if not more cheaply, than steam railways, while the earnings per mile from passengers are usually greater than on steam railways. Investors should, therefore, use the same caution in purchasing street railway securities that they would in purchasing a horse or a piece of real estate. Make sure that the title is sound, that the property has been conservatively organized and is being conservatively managed, and that the territory is sufficiently populous to make the road pay. Always keep in mind the fact that each car must carry about three passengers at 5 cents each for each mile the car runs in order to pay the expenses of operating the car.

The Association of Railway Telegraph Superintendents

Twenty-third Annual Meeting.

THE twenty-third annual meeting of the Association of Railway Telegraph Superintendents was held at Indianapolis, Ind., on June 15 and 16, and many papers bearing on the general subject of the railway telegraph service were read and discussed. Mr. A. J. Francis, railroad agent of the Chicago Telephone Company, read a paper on "The Telephone in Railroad Service," which showed the utility of the telephone in giving the public quick information relative to rates for passenger and freight traffic.

Mr. J. H. Jacoby, superintendent of telegraphs of the Lehigh Valley Railroad, presented a paper on "The Telegraph Service of To-day." This paper dealt with the changed conditions of the telegraph operators of to-day compared with those of fifteen or twenty years ago, and pointed out the difficulties in the way of obtaining a superior class of employees for the service.

Fifteen or twenty years ago the position of a telegraph operator was eagerly sought after, but of recent years the shorter hours and better pay in other lines of work, together with the fact that the more important offices in the railroad telegraph service are not open to the operator until he reaches the age of 21 years, militate against a desirable class of young men entering the service. Mr. Jacoby did not offer a solution of the difficulty. This paper was not discussed in open session.

A paper by Mr. F. G. Sherman, Jersey City, N. J., superintendent of the Central Railroad of New Jersey, on "The Economical Use of the Commercial Telegraph by Holders of Franks Issued on Account of Railroad Contracts," evoked considerable discussion. Under the arrangement between many of the railroads and the

commercial telegraph companies, a certain number of messages are sent free by the telegraph companies, but the excess over this number is charged for at a nominal rate. In the aggregate, however, this excess frequently amounts to a large sum per annum. It was contended that the bulk of the excess messages was unnecessary and could better be sent as letters by mail. The appointment of a censor of such messages was recommended, and instances were cited showing that such a censorship had resulted in reducing the charges for excess messages from over $5000 per annum to less than $100, without the slightest detriment to the railroad service.

An interesting paper was read by Mr. J. B. Taltavall, of New York, on "The Telegraph Operator in the Telegraph Service." The report of a committee appointed in 1903 to investigate the various telephone systems in operation on railroad telegraph lines, was presented by the chairman of the committee, Mr. E. P. Griffith, telegraph superintendent of the Erie Railroad. These systems, as the name indicates, consist of superposing telephone upon telegraph circuits, following the plan of C. F. Varley and Van Rysselberghe for graduating the rise and fall of the telegraph currents by means of inductance coils so that they will not affect the telephone system.

The report showed that for distances up to about 150 miles and under favorable conditions as regards induction effects from parallel telegraph circuits, satisfactory results were being obtained. One of the chief obstacles in the way of successful telephony appears to be the difficulty of obtaining a thoroughly reliable "ringing-up" device that will not interfere with the telegraph service. This report brought out considerable discussion, several of the members present stating that they were operating two Morse duplex circuits and a telephone circuit on two wires, with success, over a distance of 150 miles.

During the discussion Mr. Adams Randall, of New York, was requested to give a description of his multiple telephone transmitter, by means of which he is able to employ electromotive forces of over 40 volts in the transmitter, with the result that he can reduce the sensitiveness of the receiver to a point where it is not responsive to induction effects from parallel circuits, but yet is responsive to the talking current.

Mr. William Maver, Jr., presented a paper on "Recent Developments in Wireless Telegraphy." Mr. Charles Selden, telegraph superintendent of the Baltimore & Ohio Railroad, gave a talk on the methods of personal inspection of telegraph stations and signaling towers employed by his company whereby large economies are effected in the operation of these systems.

Mr. C. W. Hope, of the Chicago, Minneapolis & Omaha Railway, St. Paul, Minn., was elected president of the association for the ensuing year. Mr. E. E. Torrey, of the Mobile & Ohio Railroad, was elected vice-president; Mr. P. W. Drew, of Milwaukee, Wis., was re-elected secretary and treasurer.

It was decided to hold the next annual convention in Chattanooga, Tenn. The meeting was one of the most interesting in the history of the association, both as regards attendance and the importance of the subjects presented and discussed. After adjournment the convention was tendered a dinner by the Central Union Telephone Company, at the Columbia Club, Indianapolis, Ind. The majority of the members of the association afterwards left by midnight train for the World's Fair at St. Louis.

The Most Economical Amount of Feed Wire for an Electric Railroad

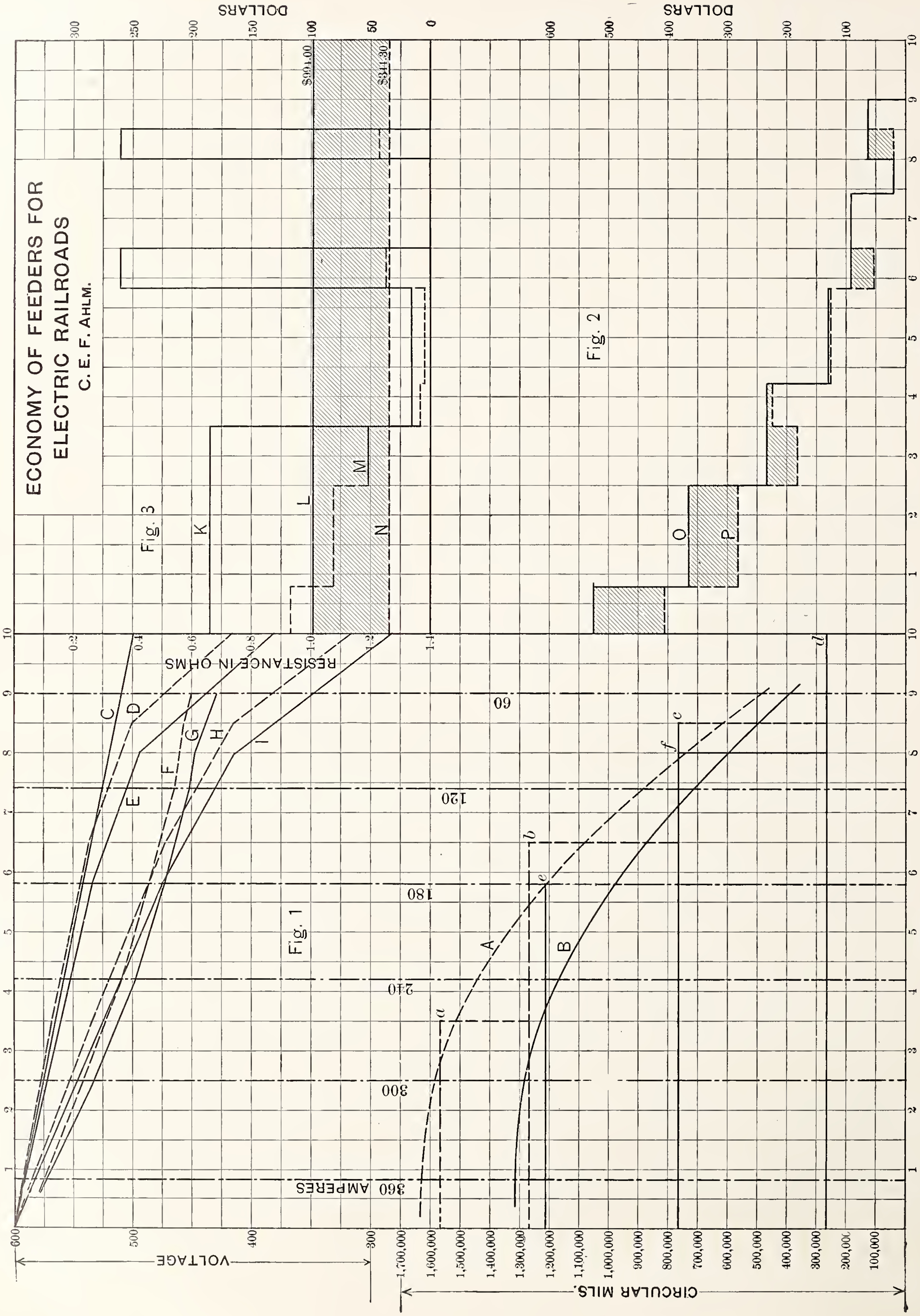
By C. E. F. AHLM

IN the February issue of THE ELECTRICAL AGE, appeared a very interesting article, written by Mr. L. W. Serrell, and entitled as above. The graphical method employed is extremely neat and useful, but should have been carried out further in order to arrive at the desired end, viz., "the most economical amount of feed wire." The results obtained give us the most economical cross-section of feed wire for a drop of 10 per cent., when, maybe, a smaller cable would be more economical if we take into consideration interest, maintenance and depreciation of the same, even if we thereby would increase the drop and accordingly, also, the watt loss in the feeder.

In the following, the writer will briefly outline his method of graphically applying Lord Kelvin's law, believing that it will be of some interest to others, as it has the advantage of being generally applicable to any case of power distribution, and still further has the great advantage of not being limited to the cost of bare copper per pound, but may include the cost of the insulated cable, as well as the cost of different methods of erection, etc.

For the purpose of demonstration, we will take the case selected in the article mentioned, having reproduced some of the curves in Fig. 1. Here curve *A* represents the theoretical feeder for a drop of 10 per cent., and the dotted, broken curve, *a*, *b*, *c*, *d*, the corresponding feeder when applied to commercial sizes, viz., 10 miles of two No. 00 B. & S. gauge trolley wires, 8½ miles of 500,000 C. M. cable, 6½ miles of 500,000 C. M. cable, and 3½ miles of 300,000 C. M. cable, all counted from the power house which is situated at the beginning of the road.

In order to simplify matters, we may assume that the track construction is approved, or that for other reasons no change in this is desirable. The feeder, however, might be changed, and we shall, therefore, investigate conditions for a drop of 12½ per cent. in order to demonstrate our method. Curve *B* is the theoretical feeder with this drop, and the full broken curve *c*, *f*, *d* is the corresponding commercial feeder, viz., 10 miles of two No. 00 B. & S. gauge trolley wires, 8 miles of 500,000 C. M. cable and 5.8 miles of 450,000 C. M. cable. Feeder *B* being the smaller one will now cause a greater amount of watt loss per annum than the larger feeder *A*, but the interest per annum of the latter will be higher as will also its rate of interest, maintenance and deprecia-


ECONOMY OF FEEDERS FOR
ELECTRIC RAILROADS
C. E. F. AHLM.
Fig. 1
Fig. 2
Fig. 3
MILES
DOLLARS
VOLTAGE
CIRCULAR MILS.
RESISTANCE IN OHMS
360 AMPERES
$991.00
$341.30

tion. Accordingly, if the difference in cost of the watt loss charged against the smaller feeder B should equal the difference in rate of interest, etc., charged against the larger feeder A, the two feeder installations would be equally economical, but if this watt loss difference should exceed this difference in rate of interest, etc., the larger feeder, A, would be more economical, and vice versa. These relations between watt loss and interest charge may most conveniently be represented graphically, as thereby not only do we gain a comprehensive view of all the details relative to our problem, but we may read the result directly off the chart.

In Figs. 2 and 3 are plotted the results of calculations incident to feeders A and B. The area under curve O represents the total cost of the watt loss per annum in the commercial feeder B, assuming 6000 working hours in the year, and that the cost of one K. W. hour delivered is $0.015; the area under curve P is the corresponding watt loss cost per annum for the commercial feeder A. The difference between these two areas, represented by the shaded portion, will then constitute the excess in expenditure per year necessitated by the use of the smaller feeder. This shaded area is reproduced on a larger scale in Fig. 3, and is there represented by the area under the dotted curve M. In the same figure the area under curve K is plotted to represent the difference in interest, maintenance and depreciation per annum between feeders A and B, taking as the cost per mile of 500,000 C. M. cable to be $2600, the 450,000 C. M. cable to be $2450, the 300,000 C. M. cable to be $1700, and the No. 00 trolley wire to be $300. Further, it is here assumed that the amount for interest, maintenance and depreciation will be 10 per cent. of the capital expended.

We have here considered only certain cost for cables alone, but we readily see that this cost might also include other initial expenditures incident to the feeder installation, and for the sake of generalization, we may consider that such is the case here. Also, this method of plotting would enable us to use a variable interest charge if the problem at hand should warrant it.

The difference, curve K, is more easily plotted directly as has been done here than by arriving at it by the same procedure by which the curve M was obtained from curves O and P. The difference between these two areas under K and M will now finally decide which feeder is the more economical one under the conditions assumed. The line L has been drawn in such a position that the area enclosed by it and the base line is equal to the area under curve K; similarly, the area enclosed by the line N and the base line equals the area under curve M; these two areas represent $994 and $344.30, respectively, and the difference between the two, or the shaded portion, equal to $649.70, represents the saving in favor of the smaller feeder, B.

The top curves in Fig. 1 represent resistances and voltage drops for the two feeder installations. Curve C gives the assumed rail resistance, and curves D and H represent resistances of feeder and of feeder and rails respectively, and with reference to feeder installation A.

The curves E and I give the corresponding relations with reference to feeder B. Curves F and G give the voltage at the cars for the two feeders, A and B, respectively, and with a load of 60 amperes.

By plotting several curves under different assumed conditions of voltage drop, etc., the most economical and also the one for the purpose best suitable, feeder installation may be selected.

The method briefly outlined above is generally applicable to all conditions, and is in principle Lord Kelvin's law, generalized and graphically treated.

Moving Pictures of Manufacturing Scenes

THE different Westinghouse Companies in the Pittsburg district, which have united with the other Westinghouse interests in the United States and Europe, in representation at the St. Louis Fair, under the title of the Westinghouse Companies at the Louisiana Purchase Exposition, recently gave a display at Carnegie Hall, Pittsburg, of "moving pictures" of scenes in and about the Westinghouse works, which was attended by 2500 Westinghouse employees. The pictures were taken for exhibition in St. Louis in the private Westinghouse Auditorium on the fair grounds, and are interesting not only as one evidence of the active preparations being made by big exhibitors for the entertaining of visitors to the World's Fair, but as a revelation of an important use of the Cooper-Hewitt mercury vapor lamps, in connection with interior photography.

The whole secret of the success attained in the remarkable photographs of shop interiors taken for the Westinghouse Companies is ascribed to the possibilities of artificial lighting by means of the Cooper-Hewitt lamp.

The Westinghouse pictures are a departure in the moving picture field, and will probably be succeeded by similar pictures taken in all branches of industry to illustrate to those unable to visit big manufacturing shops the condition of activity prevailing at a given time, the methods employed in manufacture and the general appearance of shop interiors. The biograph picture is thus seriously brought into the commercial and industrial world for the first time.

Although the greater number of Westinghouse pictures are interiors, the panoramic scenes along the route of the Pennsylvania Railroad from Pittsburg 20 miles east to Stewart and Trafford City, with views of stations along the way and of the Westinghouse works at Swissvale, East Pittsburg, Wilmerding and Trafford City, will be of special interest to Pennsylvanians at the St. Louis Exposition. To secure this series a special train was run for two days back and forth along the Pitcairn branch. Two other outdoor pictures illustrate the familiar scenes at the end of the working day at East Pittsburg. One film, six minutes' long, shows the procession of employees from one of the large doors of the works of the Westinghouse Electric & Manufacturing Company. This picture could have been made twice as long if it had been desired, but only about one-half of the 8000 employees of this one Westinghouse industry are shown. The second picture shows the departure of one of the special Westinghouse trains from the East Pittsburg station.

The interior views, however, of the Westinghouse display probably will attract most attention at St. Louis. Several of them are mutoscope pictures, in which the camera was placed about 15 feet above the ground, on a platform suspended from an electric traveling crane, and moved slowly down along the aisle about 50 feet in the rear of a Cooper-Hewitt lamp, the latter also suspended from a traveling crane moving at an equal speed.

So far as possible in these pictures, any sunlight through the glass skylights was taken advantage of, but it is not as safe to depend very much upon the help of the sun in a picture which is four or five minutes in taking, as it would be in the case of a snap-shot, especially in the Pittsburg district, where the sun plays hide-and-seek with the clouds and smoke throughout the day. On the first giant crane, with the lamps, was mounted a 500-volt motor connected to a 27-K. W. generator of 125 volts, direct-current. The sixty-four Coop-

er-Hewitt lamp tubes themselves were hung in sets of eight, in eight frames, each about 5 feet high, 3 feet wide and 4 inches deep, and fitted with resistance coils, each board taking 35 amperes at 110 volts, the entire set of lamps requiring only from 30 to 40 K. W., or about one-fifth the energy consumed by the 400 arc lamps.

The lighting of so long a string of lamps calls for some patience. They are lighted one at a time by inclining the tubes forward to distribute the mercury and then letting it drop back into place after the first few have been started. The whole scene in the immediate vicinity is swathed in a very blue, almost purple, light for a few minutes, the color gradually becoming a greenish white as the glow becomes steady. The camera shutter is very fast, 15 pictures to the second, 50 feet of film or 900 pictures to the minute, and the light must be of the highest possible approach to a clear sunlight before a successful series can be obtained. In some of the Westinghouse pictures the speed of the shutter is curiously reflected in the case of large revolving parts of big power motors or generators, which appear to be going at speeds inconsistent, either too slow or too fast, with the action of the rest of the machine. The apparent speed of the wheel depends altogether on the position of the spokes as caught by the lens in the separate pictures.

Four striking pictures are those taken in the forges at East Pittsburg and Wilmerding. Iron plates and steel billets, taken from the furnace at a white heat, are hammered into shape in fast time, while the sparks fly and the forges fires blaze up. The realistic activity of these pictures is enhanced in the case of one of them by the instinct jar seen, almost felt, every time the 30-ton hammer strikes and flattens out several inches of a 10-ton steel crank-shaft.

In all of the pictures, employees of the Westinghouse shops have displayed a very great interest. There are more than 1000 distinct likenesses of different persons, and 10,000 seats could have been filled at the private display if Carnegie Hall had been big enough to hold them. The pictures were received with cheers and laughter as the persons in them were recognized, and the evening's entertainment was added to by the display of a large number of selected films made by the biograph company for theatre use, although the Westinghouse pictures alone, if all used, would occupy over two full hours in presentation.

The titles of the pictures are as follows:—The Westinghouse Companies' special train from Pittsburg, 20 miles east on the Pennsylvania Railroad to the Union Switch & Signal Company, Swissvale; the Westinghouse Machine Company and the Westinghouse Electric & Manufacturing Company, East Pittsburg; the Westinghouse Air Brake Company, Wilmerding; and the Westinghouse Machine Company Foundry, Trafford City.

Views at Westinghouse Electric & Manufacturing Company:—

Welding 10-foot field ring—one of five 1500-kilowatt generators for Pittsburg Railways Company.

Connecting armature coils—for railway motors.

Winding field and transformer coils—for type 3 motors and transformers.

Winding small coils—for street car, type C, and type C motors.

Insulating armature coils—for motors and generators.

The end of the day—employees lifting pass checks to show at doors.

"Lightning" Static Sign, 50,000-volt potential. On view at Westinghouse exhibit in Palace of Electricity.

Railway motor aisle—weekly output 20,000 horse-power.

Two pictures: Assembling and testing one of tne seventy-seven 1500-kilowatt rotary converters made for the Manhattan elevated and subway roads, New York City.

Panoramic view—one of the main ¼-mile aisles, devoted to the construction of big power types.

When the whistle blows—Six minutes' view of employees leaving one of the Westinghouse East Pittsburg works.

Views at Westinghouse Machine Company:—

Forging 10-ton steel crank-shaft—for gas engine. "Hold tight when the 30-ton hammer strikes."

Testing gas engine—250 horse-power horizontal tandem, double-acting type, shown using natural gas.

Testing steam engines—standard and compound single-acting types.

Steam turbine test—1500 horse-power type under brake-load applied by water friction.

Inspecting and testing steam turbines—showing two of sixty 600 horse-power type in operation.

East end of main aisle—heavy machine work, showing 10,000 horse-power Westinghouse-Parsons steam turbine under construction near end of aisle.

Views at Westinghouse Air Brake Company:—

Continuous casting process—showing revolving foundry table in operation.

Brass foundry—where many of the intricate parts of the air brake are made.

Views at Westinghouse Machine Company Foundry:—

Two pictures of large casting processes.

Railway Scenes:—

Boarding the train—five-minute view of train departure at the close of day at East Pittsburg.

Safe-guarding the traveler—train approaching signal tower, showing operation of automatic interlocking apparatus.

Wireless Telegraph Government Board

PRESIDENT ROOSEVELT has appointed Rear Admiral Robley D. Evans, Rear Admiral Henry N. Manney, Brig.-Gen. A. W. Greely, Lieut.-Com. Joseph L. Jayne and Prof. Willis L. Moore as a board to consider the question of wireless telegraphy in the service of the National Government.

While no announcement has been made as to the work to be done by the board, it is understood by officers of the army and navy that it is to determine what department of the Government shall control wireless telegraphy in this country. The departments interested are the War Department, Navy Department, Weather Bureau and Department of Commerce and Labor. Each of these departments is represented on the board, and it is expected that they will include a report on the subject within a short time, which will assist the President in determining what measure of control the Government shall have over wireless telegraphy and what special department shall have charge of this work.

The board will make a thorough investigation of the subject with a view to the adoption by this Government for use by the navy of the most improved system, and at the same time for the purpose of bringing commercial companies under the control and direction of the Government in time of war.

Electricity in Pennsylvania Coal Mines

THOUGH the use of electricity underground in gaseous mines is opposed by the chief of the Bureau of Mines of Pennsylvania, and though district mine inspectors sometimes refuse to sanction the installation of electric motors, yet there has been within the past five years, says the "Engineering and Mining Jour-

nal," a notable growth in the use of electricity at Pennsylvania coal mines, and this growth will undoubtedly continue.

Two objections are frequently cited to the introduction of electric machinery, namely, the lack of a sufficient supply of labor competent to keep such machinery in good adjustment, and the difficulty and cost of repairing serious injuries or replacing broken parts. Both these objections are losing force. Large coal mining companies now have thoroughly competent electrical engineers under whom are employees that can set up a motor or string wires properly. With the steady increase in the use of electric motors for coal cutting, pumping and haulage, the ordinary miner is developing the willingness and skill to keep such equipment in good condition. Moreover, the cost of repairs has been greatly reduced by the practice, on the part of large companies, of employing efficient repair men and equipping the machine shop with everything needed for rewinding armatures, trueing commutators, and the like.

Beyond these two objections, now disappearing, to the introduction or wider use of electricity, there remain only the liability to fire from defective insulation and the danger of explosions in gaseous workings. The last objection is admittedly serious, and few advocates of electrical equipment will advise the installation of electric haulage for entries and rooms where the use of the safety lamp is imperative. On the other hand, if ventilation is as good as it should be, the danger zone may be limited and the area available for electric motors becomes correspondingly increased. The possibility of fire from defective insulation, while admittedly a risk, is often exaggerated. It is probably a less serious menace than the ordinary miner's lamp, which, in careless hands, has started so many mine fires.

The work done by electric motors at Pennsylvania collieries covers nearly all the operations of mining and preparing coal. In the bituminous region there are tipples where the chain-hauls, the crushing rolls and conveyors are driven by electric motors, while electric carriers supply blocks of coke-ovens. The largest individual coal-washing plant in the State is to have an electric equipment. In the anthracite region the Delaware, Lackawanna & Western Company has a small electrically equipped breaker in operation, and is preparing to start work on a very large breaker similarly equipped. The Delaware & Hudson Company is to use electric motors in a medium-sized breaker near Wilkesbarre. Mine fans of large capacity are now driven by electric motors. When fans are situated some distance from a boiler plant, the economy, compared with a steam line, is considerable, and more fans would be so driven but for the conservatism of mine inspectors.

The use of electric locomotives underground, where conditions are favorable, is on the increase in both the anthracite and bituminous regions. Several electric manufacturing companies have built locomotives with a reel carrying several hundred feet of insulated cable by which a locomotive can run up into rooms or headings where no trolley wires are strung. For grades of from 3 to 20 per cent. an electrically-propelled rack-rail locomotive has given excellent results at some mines in the Clearfield region, and several manufacturing companies are preparing to build locomotives of somewhat similar type.

Coal-cutting machines are not used in the anthracite region, though electric drills for rock work are being given a thorough test in the Scranton district. In the bituminous regions electric undercutting machines are in common use.

The use of electricity for pumping calls for some comment, in view of the development of the multi-stage centrifugal pump for high heads. At present some large horizontal plunger pumps in the anthracite region are electrically driven; in the bituminous regions triplex electric pumps are often seen. While slope hoists electrically driven are fairly numerous in the anthracite region, there are as yet no mines in the State using electric hoists in the main shafts. However, the great water-hoist of the Delaware, Lackawanna & Western Company near Scranton is to be equipped with electric motors, and will be an advance over anything in this country or abroad, in view of the heavy duty required.

Electricity at Purdue University

THE thirtieth annual commencement of Purdue University, at La Fayette, Ind., was held on Wednesday, June 8. The graduating class numbered 187. Advanced degrees were conferred on twelve candidates, and the degree of Doctor of Engineering upon Elwood Mead, class of 1882, chief of the Bureau of Irrigation, Department of Agriculture of the United States.

Of the graduates in electrical engineering, Messrs. F. H. Miller, F. Riebel, Jr., Hartley Rowe, F. H. Nealis, H. Berthold, R. H. Davidson and L. J. Kirby have entered the employ of the Westinghouse Electric & Manufacturing Company; J. G. Anthony, that of the Bullock Company; L. D. Waldron, the Commercial Electric Company; R. G. Mansfield and M. E. Weidner, the Stanley Electric Company; J. M. Reynolds, the Western Electric Company, New York; J. R. Gregory, W. J. Drury and C. E. Layton, the Western Electric Company, Chicago; Clyde Keirn, the Chicago Edison Company; R. M. Harris, the electrical department at Purdue University; C. C. Bradbury, the Underwriters' Laboratory, Chicago; W. M. Hinesley, the Dayton Railway Company, Dayton, Ohio; W. C. Martin, the Arnold Electric & Power Station Company, Chicago; H. E. Smiley, the Chesapeake & Ohio Telephone Company, Baltimore, Md.; A. P. Wood, the Fort Wayne Electric Works, Fort Wayne, Ind.; C. E. Kailer, the Indianapolis & Northwestern Traction Company, Lebanon, Ind., and H. H. Arnold, the Indianapolis Light & Power Company, Indianapolis, Ind.

National Electric Light Association Membership

AT the twenty-seventh convention of the National Electric Light Association, held in Boston last month, an amendment to the constitution was adopted dividing the membership into six classes, as follows:

Class *A*, Member Companies:—Private corporations or individuals engaged in the business of producing and supplying electricity for light, heat or power for commercial or public use. Entrance fee, $25; annual dues for companies in towns of less than 20,000 population, $10; 20,000 to 300,000, $25; over 300,000, $50.

Class *B*, Members:—Officers or employees of member companies, elected and continued from year to year with the written consent of the member company with whom connected. Entrance fee, $5; annual dues, $5.

Class *C*, Instructors and Teachers of Engineering and Related Sciences:—No entrance fee; annual dues, $4.

Class *D*, Associate Member Companies:—Electricians, electrical or mechanical engineers, manufacturers, corporations or individuals, who are directly or indirectly interested in advancing the interests of electricity. Entrance fee, $25; annual dues, $20.

Class *E*:—Officers and employees of Class *D*, elected and continued by written consent of the Class *D* member employer. Entrance fee, $5; dues, $5.

Honorary members.

Limitations of Long-Distance Electric Power Transmission

By PAUL M. LINCOLN

Reprinted from the Electric Power Number of "Cassier's Magazine."

HOW far can power be transmitted electrically?

What is the cost of transmitting electric power?

What per cent loss takes place in transmission?

These will be recognized by any electrical engineer as typical of the questions that are continually being asked by the investor in electrical enterprises, by the users of electric power and by the interested layman in general. The writer has been called upon so often to answer these questions verbally that a written analysis of the elements which enter into the answers of these questions has occurred to him as likely to be acceptable. No direct answer can be given, as the answers depend upon many and varied elements, a change in any one of which may change the entire complexion of the problem. It is the intention in the following pages to present briefly the principal elements that enter to limit the distance and profitableness of electric transmission. The conditions forming the limits may be roughly divided into two classes:

I. The limits as placed by commercial considerations, that is, the limits beyond which electrically transmitted power ceases to return a profit.

II. The limits as placed by engineering considerations.

I.—COMMERCIAL LIMITS

The crucial question in any commercial enterprise, and an electrical transmission scheme is always a commercial enterprise, is, will it pay? There is no real limit beyond which it is impossible to deliver electric power, provided no limit be put upon the amount of money to be spent. The engineer could easily be found who would undertake to deliver Niagara power in South Africa. The difficulty would be to find the financier to put up the necessary cash. The law of supply and demand operates no less in the realm of power transmission than in any other department of commercial enterprise.

If the price that could be demanded for power in South Africa were sufficient, say, a million times its present cost, the idea of delivering Niagara power to that region would not seem the absurdity that it is under present conditions. In fact, there are in operation to-day dozens of transmission lines exceeding 3000 miles in length that have been for years transmitting power successfully, both from an engineering and from a financial standpoint.

The success of these enterprises is simply a question of the price which can be successfully demanded for the power delivered. In the case to which reference is made, this price is perhaps one billion times that for which Niagara power is sold in Buffalo, or say, $25,000,000,000 per K. W. per year. The writer refers to the transmission of energy in the Atlantic cables. The motion of the syphon recorder at the end of the cable is just as truly the result of power transmission as the running of a printing press or the driving of a factory. The same laws of transmission apply, whether the power transmission be used for operating the syphon recorder or the factory. It is in the value of power transmitted that the great difference lies. If the power for driving factories were worth as much as that for operating a syphon recorder, Niagara power would, perhaps, have been sold in the markets of Europe long before this.

The distance, therefore, to which power can be successfully transmitted by electricity depends almost entirely upon the price which can be successfully demanded for such power. The price is regulated by the law of supply and demand. The power user will buy power where he can get it cheapest and will install his own steam plant, unless the power transmission company can sell him power as cheaply as he can generate it. The most important single item in the cost of steam power is the cost of fuel. An electric transmission scheme which might fail utterly among the coal fields of a country, with coal at, say, $1 a ton, might succeed brilliantly in places where coal costs $10, or in South Africa, for example, with coal at, say, $50 a ton. The cost of electrical power delivered at any point, which must be compared to the cost of power at the same point as obtained from other sources, may be divided into three quite distinct elements:

1. The cost, at the generating station, of the power delivered to the customer at the other end of the line.

2. The cost, at the generating station, of the power lost in transmission.

3. Interest, depreciation and maintenance of the transmission plant.

It is so evident as only to need mention, that, other things being equal, the longer the transmission, the greater the cost of the power delivered at the end of that transmission. The question that invariably confronts the electrical engineer is to deliver a given amount of power, under certain given conditions, at the minimum cost.

It may be noted that the last two items as given above vary inversely with each other, that is, for a given proposition, if we increase the amount of copper, which is the principle upon which the third item is computed, we evidently will decrease the amount of power lost, which is the second item of cost. Lord Kelvin, in 1881, showed that the total cost for transmitting power would be a minimum, in other words, economy would be a maximum, when these two variable elements became equal to each other, that is, when the annual cost of power lost in transmission became equal to the annual interest, depreciation and maintenance charge on the transmission plant.

Later, other writers on the same subject drew attention to the fact that there were elements in item No. 3 of the cost that are independent of the amount of copper used, and, therefore, are independent of item No. 2 of cost. They then went on to show that maximum economy was secured when the variable element in item No. 3 became equal to item No. 2.

The constant element of the transmitting plant occurs in such things as the cost of the right of way, cost of necessary transformers, and a certain proportion of the cost of the support-

ing structure. The greater part of the variable element lies in the weight of conductors used in transmissions, and a much smaller element in the cost of necessary insulation.

It follows, therefore, that if we design a transmission plant for maximum economy, the percentage increase in cost of power at the receiving end over the cost of power at the transmitting end is at least double the percentage loss. For instance, if we find that 10 per cent. loss, in a given transmission proposition, gives maximum economy, the cost of power at the receiving end must be at least 20 per cent. greater than at the generating end.

In order to make electric transmission of power reliable, it is necessary to provide a certain excess capacity in the transmission line or lines, and to provide spare apparatus for use in case any part of the system becomes damaged. The cost of these spare parts, the price of reliability, should be added to the cost sufficient under normal conditions, and forms another item of expense. The amount of this item is dependent, of course, upon the importance of the service and is governed by local conditions.

The expense of the necessary right of way is another element in the cost of transmission, which is dependent upon local conditions. It is evident that a right of way between Niagara Falls and Buffalo, for instance, would be much more expensive than that through a mountainous district of an out-of-the-way part of the country.

The problem of electric transmission is, therefore, largely a commercial problem. From the above analysis we might expect that the transmission of power would be most highly developed in the localities where any or all of the following conditions exist: First, where competing power is expensive from any cause, such as high-priced fuel, scarcity of water, expensive labor or poor transportation facilities. Second, where water powers are abundant and easily developed and where, therefore, the raw material of the enterprise is cheap. Third, where the demand for power is extensive.

Along the Pacific Coast of the United States these conditions are closely met. Water powers are there abundant, fuel is expensive, both on account of its scarcity and difficulty of transportation. All along the coast from southern California to northern Washington and even into British Columbia, the energy of the mountain streams is a commodity that can be purchased in almost any city and town and in many of the villages.

The "white coal" of the Alps, so-called from the snow caps which form the sources of the mountain streams, is in great demand in Switzerland and the neighboring Alpine countries. There is now under serious consideration a scheme for transmitting to Paris power developed from these mountain streams of the Alps, about 300 miles distant. It seems probable that this transmission will be one of the engineering realities of the near future.

The development of Niagara Falls is too well known to discuss at length, but the region is one where coal is not expensive and still electrically transmitted power finds an almost unlimited market. The distance, however, to which power in the northern part of the State of New York can be transmitted and sold at a profit is not so great as it would be in California or in South Africa, where fuel is much more expensive and transportation facilities are inadequately developed.

II.—ENGINEERING LIMITS

The present state of the art of long-distance transmission is the result of evolution. No engineer is prepared to believe that this process of evolution has just begun and that epoch-making and revolutionary improvements in the art of long-distance transmission are impending, as some electricity-in-its-infancy paragraph writers would have us believe. On the other hand, no engineer is prepared to believe that the process is complete, or that the art has reached its acme of perfection. Somewhere between these two extremes lies the truth. It is fair to assume that as perfection is more closely approached those limitations of a technical nature, beyond which we cannot see our way clear to advance at present, will be gradualy extended by the experience of the future to a point higher than that attainable now.

The principle thing which at present limits the distance to which power can be transmitted is voltage, or rather insulation. The amount of copper, which constitutes a large proportion of the total cost of any given transmission scheme, is directly proportional to the square of the distance and the amount of power transmitted, and is inversely proportional to the square of the voltage used and the loss that takes place in the conductors. Algebraically expressed, this law is:

$$\text{Weight of copper} = \frac{\text{K. W. x miles}^2}{\text{Loss x voltage}^2}$$

It is evident, therefore, that if we could increase the voltage indefinitely, we could increase the transmission distance indefinitely; but we soon come to a limit beyond which we find it is impossible to increase the voltage. Just what this limit in voltage is at present is somewhat a matter of indivual opinion, and what it will be in the future involves an exercise of prophetic vision which it is beyond the scope of this discussion to assume.

The highest voltage actually in use at the present time is about 55,000. This voltage is used in the Canon Ferry-Butte transmission in Montana, a distance of about 65 miles, and in the Shawinigan-Montreal transmission in Canada, a distance of about 80 miles. Higher voltages have been proposed, and in some cases have even been prepared for, in the design of lines and transformers; but up to the present time none higher than 55,000 volts has been put into successful commercial operation.

The most serious difficulties encountered in increasing the voltage of transmissions are:

1. Difficulty in maintaining perfect insulation.
2. Difficulty in obtaining proper protection from lightning discharges and other static troubles.
3. Loss of power due to brush discharges from high-tension conductors.
4. Deterioration of the high-tension conductors, due to the fact that compounds which attack the metal are formed by the action of these brush discharges upon the atmosphere.

As before stated it is beyond the scope of this paper to place a future limit to voltage increase, but present indications are that no increases of a revolutionary character may be expected in this direction, at least not in the immediate future.

Another condition which falls under the head of an engineering limit is occasioned by what the electrical engineer calls regulation. In order to give good service, the voltage at the consumer's apparatus should be practically constant under all conditions. If the voltage is not constant, there is a variation in the illumination of the customer's lamps and in the speed of his motors which he is apt to find exceedingly annoying, and which, if not corrected, will lead him to seek some other source of light and power.

Now, in order that the voltage shall be constant at the receiving line, which usually means practically constant on the consumer's apparatus, the voltage at the generating end must increase as the load transmitted increases. The percentage increase in voltage at the generating end between no load and full load on the transmission line in order to maintain a constant voltage at the receiving end is called regulation. Regulation is a function of the loss which takes place in any transmission; the greater the loss, the poorer the regulation.

In very long transmission lines, in order to obtain maximum economy, the loss increases with the distance,

and usually we find that in order to obtain maximum economy in long-distance lines there will be a regulation considerably worse than that demanded by good service. That is, if we could increase the loss in transmission over that fixed by the worst allowable regulation, the saving in the cost of the transmitting plant would overbalance the cost of additional power lost. For very long transmissions, therefore, Kelvin's law is ruled out by other considerations, and the cost of transmission is thereby made higher than if the law could be applied.

The question now naturally arises, what is the maximum allowable loss that will not exceed the worst allowable regulation? This is a question of the character of service and load, the regulation of generators, the efficiency of the governing apparatus, and, to a considerable extent, a matter of individual opinion. Probably no electrical engineer would care to recommend the installation of a transmission line in which he must generate 30 per cent. more volts at full load than at no load in order to maintain a constant voltage at the receiving end. The percentage loss which is entailed by a 30 per cent. regulation is a somewhat intricate function of loss, character of load, frequency, etc.; but in common practice, as it exists to-day, it would rarely exceed 20 per cent.

There are methods whereby this element of regulation can be eliminated, for instance, the use of motor-generator sets at the receiving station, the speed of whose motors is practically independent of the voltage applied. This, however, means more aparatus, with additional cost, maintenance and liability of breadown to be balanced against the saving its use would accomplish in the cost of transmission.

The writer does not wish to have the reader get the impression from this discussion that it is always necessary to adopt a very high voltage for transmitting electric power. High voltages bring troubles of their own, and a large amount of such troubles can be avoided by using common sense in the selection of the voltage. A 10, 20 or 30-mile transmission can be carried out with voltages which are comparatively low and still not run the cost of transmission to a prohibitive figure.

A very handy rough-and-ready rule for estimating the cost of copper in any given transmission is this: If the voltage of transmission in thousands of volts is equal to the miles of distance, the cost of copper for that transmission, assuming copper at 20 cents per pound, will be very close to $5 per K. W. transmitted. This is based upon the assumption that the loss is 10 per cent.

For other losses, other distances and other voltages the formula on page 131 can be readily applied to obtain the cost of copper. For instance, if the miles of transmission are double the number of volts expressed in thousands, the cost of copper will be four times that stated above, or $20 per K. W. for a 10 per cent loss. If in this case the loss be increased to 20 per cent., the cost of copper will be one-half, or $10 per K. W.

The total cost of any transmission scheme, including cost of generating station with all appliances, cost of prime movers and buildings, cost of receiving station, will probably be at least $75 per K. W. and usually much more. It is evident, therefore, that we can keep the proportionate cost of the transmitting plant comparatively low by adopting moderate voltages, unless the distance of transmission becomes considerably greater than that which the engineer has usually to provide for.

Another class of limiting conditions in long-distance transmission, which may be mentioned in passing, is what may be called legal restrictions. The possibility always exists that laws will be passed to limit voltage on the score of the dangers to a community. In the United States it has so far been found unnecessary to invoke the aid of the law. Of more importance are the rules which have been and will, in the future, be established by the various boards of underwriters. A rash and ill-considered rule, which might be made and enforced by the fire underwriters, might prove exceedingly disastrous to the art of long-distance transmission. That proper precautions should be taken to protect life and property admits of no discussion. The remedies of such evils lie in regulation and not in strangulation.

While in the foregoing we have a rather brief and purely abstract analysis of some of the main elements entering into the problem of high-tension transmission, the assumption and solution of one or two concrete examples may assist to a more thorough understanding of the matter.

Suppose therefore that we assume a 25-mile transmission at 25,000 volts. Assume copper at 20 cents a pound, and let the interest, depreciation and maintenance and taxes on the cost of the copper in the transmission plant be taken at 12 per cent. Assume further that it costs $20 per K. W. per year to generate power. The question in which both the promoter and the engineer of such an enterprise is particularly interested is, what is the cost of transmission? Given the assumption above, this question can be answered at least partially. A complete answer will require more complete data. We have already seen from the approximate rule on this page that, assuming conditions as above, the investment in copper is $5 for a loss of 10 per cent., and that for other losses the investment is in inverse proportion. We have seen also that maximum economy will be obtained when the annual interest charge on this is equal to the annual value of power lost. At a loss of 10 per cent. these two elements are not equal, but we find that reducing the loss to about 5½ per cent., thereby raising the investment in copper to about $9, the two elements became very nearly equal. One becomes 12 per cent. of $9, or about $1.08, and the other becomes 5½ per cent. of $20, or $1.10. The cost of power, therefore, at the receiving end will be at least 11 per cent. greater than at the generating end.

This is as far as our answer can go. The amount that the 11 per cent. will have to be increased to obtain the actual figure will depend upon the additional investment necessary for transformers, right of way, etc., as well as upon the load factor. By load factor is meant the ratio of the average to the maximum load on the system.

Investment and, therefore, interest, etc., depends upon maximum load. This item is active twenty-four hours per day and every day. The returns on the investment or the amounts received for power sold depend very largely upon the time during which power is used. If, for instance, the power can be used only during two hours of the twenty-four, it is evident that the proportionate cost of transmission must be higher than if the power were used the whole twenty-four hours. Neither has the figure given above taken into account the necessary investment for spare lines, etc.; all these elements tend to increase, and none to decrease, the 11 per cent., as figured above.

The writer has mentioned the proposed transmission from the Alps to Paris. A few figures showing the minimum cost of transmitting power this distance—300 miles—may be of interest. The first question is what voltage and loss to use. Assume first that the consideration of regulation will limit loss to 15 per cent. The regulation imposed by this loss depends upon the frequency chosen and the character of the load, but probably will be not less than 25 per cent. Fifty thousand volts delivered in Paris, therefore, will mean the use of a voltage higher than any in use at present, but still a voltage within the bounds of reason.

Applying the rule and formula given on page 387, we find that the

cost of copper for these conditions is about $120 per K. W., copper at 20 cents a pound. Assume that additional investment per K. W. for right of way, transformers, supporting structure, etc., will be as much more, making a total investment of $240 per K. W. for transmission alone; at 12 per cent. the annual cost will, therefore, be $28.80. Add to this the value of the power lost per K. W. transmitted—15 per cent. of, say, $20—and we have a total of about $32 per K. W. This will be the cost per year to transmit one K. W., provided we assume a load factor of one.

This figure is, of course, subject to wide correction, as the assumptions made may vary from the truth. The examples are given to illustrate method rather than to give actual figures. In the last example it will be noted that Kevlin's law does not apply. If a worse regulation and a higher loss were allowable, the cost of transmission could be considerably reduced.

The limitations that have been treated in this discussion up to this point are those which affect the design of the transmission plant. As soon as we come to the matter of operation another type of limitation enters the problem. No matter how well dedesigned a transmission line may be, difficulties will arise in operation that it is impossible to foresee or take care of in the design. While it will be impossible to mention all of the troubles to which the operator of a high-tension transmission line is subject, an account of a few of them will probably be of interest.

While perhaps not the most frequent, certainly the most exasperating trouble with which a transmission manager has to contend is malicious interference. It is a difficulty over which an improvement in methods has little effect, and an improvement in apparatus none. It is a difficulty not due to the weakness of the line, but to the frailty of human nature. Sometimes such trouble arises from an actual intention to do harm, as, for instance, a feeling of spite on the part of a discharged employee. More often, however, the culprit does not realize the amount of damage and inconvenience his careless act may cause. All that the hunter finds is that the insulator makes a good target for his rifle and all that the small boy knows is that a piece of baling wire over the line will make a most interesting display of fireworks.

Neither the hunter nor the small boy realizes that his act may throw a whole city into darkness or stop trolley cars miles away. Whether done maliciously or carelessly, detection is difficult. A transmission line is open to attack anywhere along its entire length. Often these lines are run through a sparcely settled country, and a patrolling sufficient to prevent all mischief is practically impossible.

One notable instance in which malicious interference became a serious problem occurred in the high-tension transmission plants which take power into the City of Mexico. In that region the favorite implements for causing trouble on the lines were the leaves of the maguay plant, a sort of cactus. The leaves of this plant are very largely composed of water, and are, therefore, good conductors of electricity, at least for the high-voltages. The native's chief delight seemed to be in throwing these leaves over the high-tension lines and watching the resultant fireworks. All other expedients failed and it finally became necessary to ask the Government to detail a cavalry guard to patrol some of these transmission lines, with orders to "shoot to kill" anyone found interfering with them.

Another Mexican expedient is most ingenious, and certainly shows a sense of humor that one would hardly expect to find in a Mexican. A native was caught "red-handed" in the act of throwing a maguay leaf upon one of the transmission lines. He was immediately taken before a Mexican judge, and the case was clearly proved against him. The judge sentenced the culprit to one year in jail, and then suspended the sentence—and this is where he displayed real genius—until the next maguay leaf should be thrown upon the transmission line, no matter by whom. This practically gave the Mexican the choice of going to jail for one year or constituting himself a committee of one to patrol the line and see that no further interference occurred.

In connection with this the experience of one of the Westinghouse Company's engineers is brought to mind. A certain South American government was developing a water-power for the purpose of lighting an adjacent town. Before the plant had been accepted a revolution broke out, and the transmission line, being a Government institution, was fair game for the revolutionists. First they tried dynamite on the power house; but a strict guard was kept after the first attack, and further attempts in this direction were thus prevented. A new method of attack was to cut the transmission lines. The plant was used for lighting only, and the current was shut off during daylight hours, at which time this cutting could be done with safety. After fixing up one or two cuts, however, the engineer's next move was to keep the power on the line continuously. The effect was immediate. To quote the words of the engineer's report literally: "Next morning there were two new faces in Hell for breakfast."

Man, however, is not the only animal guilty of interfering with transmission lines, although he is probably the only one that does it with malice aforethought. In some localities large birds are a considerable source of trouble. In a number of instances short circuits have been due to cranes getting tangled with the high-tension wires. In other sections owls seem to be large enough to get between the transmission conductors. On the Niagara-Buffalo transmission line there were two occasions when a cat—not the same in both cases, however—managed to short-circuit the line by getting its body between adjacent conductors.

Lightning is another difficulty with which the operating engineer has to contend. Although arresters of greater or less efficiency have been devised, absolute protection from the effects of lightning is impossible in the present state of the art. During a thunderstorm the manager can never feel absolute assurance that his apparatus is safe from destruction by lightning. Electrical apparatus is somewhat peculiar in regard to damage by lightning in that a direct stroke is not necessary. The electrical pressure from the dynamo is constantly present, and it only needs a temporary break in insulation which may be made by a "side flash" to give it the opportunity of flowing in forbidden paths and so causing damage. A partial analogy to this condition may be found in a river kept within its banks by levees. A rift, in itself almost beneath notice, becomes a menace as soon as the pressure of water from the swollen river bears upon it.

It is essential that the transmission line manager shall have means of communicating between the different parts of his system. The usual method of securing it is by means of a telephone system, the conductors of which are usually on the same poles as the transmission wires. Proper maintenance of this communicating system is another difficulty that confronts the manager. The proximity of the high-tension conductors to the telephone wires does not help matters. The importance of making such a disposition of the wires that interference will be a minimum is obvious.

Many of the difficulties mentioned above can be foreseen, and, in a measure, provision can be made for them. For instance, interference by the malicious and careless can be remedied to a considerable extent by elevating the transmission conductors. But the higher the conductors are placed, the

more expensive is the construction. The question is how far can we afford to elevate the wires in order to obtain the additional immunity from interference that such elevation will give? Each case has a different answer. It is the duty of the engineer not only to be familiar with the troubles that have occurred in transmission plants and the troubles that are liable to occur in any specific plant, but also to be familiar with the remedies for these troubles so far as they exist.

It is not a simple question, therefore, which the engineer has to decide when he specifies a transmission scheme. The elements that enter his problem are many and extremely varied in character. The items that the engineer must consider before an intelligent answer can be given to the promoter with a transmission scheme form an interesting list. They are:

Voltage to be adopted.
Frequency to be adopted.
Regulation to be adopted.
Efficiency to be adopted.
Prices of copper.
Cost of poles or other supporting structure.
Cost of labor.
Cost of transportation.
Price of coal.
Cost of power at generating end of line.
Value of right of way.
Interest rate on investment.
Proper charge for maintenance.
Proper charge for depreciation.
Taxes.
Load factor, i. e., ratio of average to maximum load.

All these factors the engineer must bear in mind. It is his business to know what influence a variation in any factor will exert in the final result or in any other factor. It is his business to know not only the general considerations which enter his problem, but also to make himself thoroughly acquainted with the special considerations which invariably enter any specific case. The fact, too, that wide variations of opinion exist on some of the points, even among those best qualified to judge, does not lighten the burdens of the high-tension engineer.

To observe the tendencies of present practice; to become acquainted with those things that are proving successful in practice, as well as those that may be expected to succeed in theory; to formulate laws to connect the seemingly discordant elements of his problem; in short, to bring harmony out of apparent chaos, these are the functions of the electrical engineer.

Proposed Government Control of Wireless Telegraph Coast Stations

By WM. MAVER, Jr., Author of "Wireless Telegraphy: Theory and Practice."

IT was recently reported from Washington that the United States Government, through the Navy Department, had determined on acquiring by an enactment of Congress exclusive control of the use of wireless telegraphy on the coasts of the United States, on the ground that experience had shown that in no other way could interference between various wireless telegraph systems be prevented, the result of such interference being that no system could be relied upon to give satisfactory service.

A further reason for this proposed action is that without such exclusive control of all such stations the sea coasts cannot be properly defended in time of war, the idea doubtless being that to ensure a proper defense of the coasts, so far as wireless telegraphy can accomplish that end, it is highly essential that the various stations be equipped with the most approved wireless apparatus and manned by expert operators, all under one system of operation and control, and that these stations be absolutely safeguarded against outside electrical interference with signals in time of war, except what may be set up by an enemy. In the existing state of affairs it has been found practically impossible to make satisfactory long-distance tests of different systems, owing to the disturbances set up by other wireless systems. To illustrate the nature of this interference by way of analogy, let us assume a small float to be placed in one part of a pond, and that this float will rise and fall in accordance with water waves excited at a distance by any suitable means. To carry out the analogy we have further to assume that by some means the water waves will be promptly damped when the exciting cause is removed, and hence, that a means of telegraphing may hereby be afforded by setting up water waves of long and short duration, corresponding to a telegraph alphabet, that will cause the float at the receiving point to move up and down concurrently with the transmitted waves. It is obvious that when one set of waves only is being sent over the surface of the pond it will be a comparatively easy matter to read the movements of the float. But if two or more sets of waves are being set up at one time over the surface of the pond, the float will be agitated in a manner that will not be intelligible to any one, and all attempts at adjustment of the float to respond to the water waves set up at a given transmitting station will be futile. In a similar way the ordinary coherer of a wireless system attempts to respond to all the electric waves in its vicinity, and if two or more sets of such waves are being transmitted through the ether, neither of them are translatable.

This conclusion as to the impossibility of preventing interference from outside sources, will perhaps be vigorously contested by some of the private wireless telegraph companies, whose favorite claim has been that their systems are not susceptible to interference from signals originating in other systems; in other words, they assert that by suitably tuning and adjusting their receiving float it will respond only to one particular set of etheric waves, and therefore it would only be necessary to employ their particular system to avoid such interference. This claim, however, has been made so frequently during the past three or four years without any practical evidence being adduced to prove its accuracy, that it may be disregarded. In saying this it is not disputed that appropriate means for obtaining tuning and resonance effects are beneficial in securing the best results in long-distance wireless signaling, but experience has shown that a wireless system may be so attuned as to respond at a greater distance to one set of waves than another and yet be responsive to other sets of waves of sufficient strength. Besides, it is generally admitted that for coast station service a wireless system attuned to respond to a given set of waves only, is not desirable, for the reason that the apparatus at such stations should be capable of responding to signals from every passing vessel, regardless of the

system employed on that vessel. For a similar reason the wireless equipments on ships should obviously not be limited to one set of waves.

Doubtless the Government will also desire to use whatever system or whatever combination of wireless systems it may have found to be most efficient in the practical experiments which its various departments have been carrying on for several years, and as it is known that those systems have been found vulnerable to outside interference from other wireless systems beyond the present control of the Government, it is but natural, in a situation where the national safety may at sometime be endangered, that it should be desired to place the control of all coast stations under the exclusive jurisdiction of the Government, so that all necessary experiments and the systemization of the work may go on unhampered. Whether this work can best be done by the Army or the Navy Departments, or by both jointly, remains to be determined.

It is, of course, within the possibilities that further improvements in apparatus and methods will sooner or later give freedom from the interferance referred to. Furthermore, when the telephone is used as a receiver it has been found by De Forest, Fessenden and others, that the simultaneous occurrence of two or more sets of electric waves does not necessarily preclude the reception of messages, inasmuch as an expert operator is frequently able to select the signals intended for his station and ignore the others. But nevertheless, such more or less conflicting signals are evidently not conducive to best results where careful experiments are to be made.

Recognizing, however, that the commercial and maritime interests of the country are much concerned in the continuance of the present facilities afforded by the coast stations of private wireless companies, the proper department, preliminary to obtaining the control of all wireless coast signaling, proposes to take the place of these companies in this matter, and, in fact, to extend the use of wireless telegraphy along the coast by the erection and equipment of numerous additional stations on the Atlantic and Gulf coasts from Maine to the Dry Tortugas, and also to erect two stations on the Pacific coast, two in the Philippines and one at Honolulu—a total of over fifty such stations.

At all of the coast stations the Government contemplates transmitting and receiving messages to and from passing vessels without charge, but in so doing it is understood that the Government will not assume responsibility for the accuracy or prompt delivery of such messages. This is a feature of the plan that perhaps may not work out altogether satisfactorily, for unless some kind of responsibility is assumed for the accurate and fairly prompt handling of telegrams to and from passing vessels, a rather inefficient service may result. The free service feature may also lead to an accumulation of somewhat valueless messages to the detriment of messages of real importance, unless a judicious weeding out of the important from the unimportant messages could be ensured. In several European countries the governments accept and forward wireless messages to and from passing vessels at a fixed rate, the control of this service usually being under the post office departments, and so far as known this service is satisfactory.

It is probable that one of the most serious difficulties that will be encountered in the operation of the Government's wireless telegraph system will be to obtain proficient operators to man the stations, a fact which the officials most concerned obviously fully appreciate, as may be judged by the stipulated qualifications of the men for whom the Chief Signal Officer of the Army is now advertising.

To properly manipulate the apparatus used in wireless telegraphy, a considerable amount of expertness and technical knowledge is required on the part of the attendant; indeed, it may be said, without exceeding the bounds of strict accuracy, that a high degree of expertness is essential. It will not do, for instance, to suppose, as laymen are apt to do, that the operator of an ordinary Morse telegraph station will be able off-hand to operate a modern wireless telegraph station. Nothing could well be simpler than the apparatus of a way-side Morse telegraph station, the outfit of which comprises merely an easily adjusted Morse relay and sounder, a key and a cell or two of blue-stone battery.

It is quite different in the modern wireless telegraph station, where usually an oil engine is employed to drive a dynamo-machine for setting up electric waves and where there are also several inductance and induction coils, and several batteries of condensers, besides the coherer or other detector, the receiving relay and other receiving apparatus. Or if the oil engine and dynamo-machine are not used, a storage battery with means of charging it, together with large induction coils, vibrators, interrupters, etc., must be employed.

The attendant at the wireless station must, therefore, be capable of running an oil engine and a dynamo-machine, and must be able to make small repairs on those machines. He should also be thoroughly familiar with the operation of the rest of the apparatus of the station, which is not the simplest imaginable. Besides being a technical expert, the wireless operator should also be a good Morse operator if he is to be expected to transmit all the messages that are to be offered for transmission and reception. Ordinarily these qualifications, namely, that of technical expert and capable telegraph operator, do not require to be combined in one man; but in wireless telegraphy it is almost an essential that the technical expert shall be able to transmit and receive messages in order that he may obtain best results in the adjustment of the apparatus. Furthermore, if these qualifications are not combined in the one man, it will mean the employment of two men at each station during presumably the greater part of the twenty-four hours of a day. While, therefore, it seems evident that more than ordinary telegraphic skill will be required to operate the proposed wireless stations, there is no doubt that men of the requisite ability are procurable if sufficient inducements should be forthcoming. But whether these men can be found in sufficient numbers among the enlisted men of the navy, and, if found, can be retained permanently, is perhaps a questionable point.

Another very important point to be considered will be the location of the various coast wireless stations, for inasmuch as the best situation for a wireless station is directly on the coast, such a situation will place the station where it will be most exposed to attacks from an enemy's warships, a shot or two from which en passant would doubtless end the usefulness of the station, by prostrating the mast that upholds the vertical wires on which the success of the station depends. A location, therefore, not too exposed and yet not so far inland as to unduly diminish the signaling distance of the stations, will possibly be sought, in addition to the regular coast stations, and balloon and kite equipments for emergencies will, no doubt, also receive attention, together with many other important details that need not be here mentioned.

In the event of the enactment of the proposed legislation by Congress, it seems evident that its effect upon trans-Atlantic wireless telegraphy, at least by private concerns, may be to place it in the background, unless, as in the case of the arrangement for wireless circuits from Key West to Panama, Porto Rico and elsewhere, recently made between the United States Navy Department and the De Forest Wireless Telegraph Company, the right to transmit private and com-

mercial business shall be allowed to continue in the hands of the private companies, while the Government erects and controls the wireless stations and has free use of the apparatus. Such an arrangement would probably aid, rather than embarrass, the private concerns. Besides, there still remains the possibility of establishing private stations outside the jurisdiction of the United States Government, should the practicability of commercial transatlantic wireless telegraphy be hereafter demonstrated.

So far as the general employment of wireless telegraphy is concerned in what many have stoutly contended to be its natural field of usefulness, namely, the giving a long-desired means of communication between ships at sea and between ships and the mainland, this intimated action of the United States Government should not be an impediment, but rather the contrary, inasmuch as it will largely increase the number of coast stations, will reduce, if it does not eliminate, the cost of signaling to the sea-going public, and will tend to standardize the types of apparatus and methods of signaling, which results in themselves should lead to a decided enhancement in the general usefulness of wireless telegraphy.

Losses in the Sheaths of Alternating-Current Cables

It often happens in electrical work, according to M. B. Field, in a paper read before the London Institution of Electrical Engineers, that the mechanical engineer is prevented from making what to him appears a sound mechanical job by reason of some more or less obscure electrical condition which would be violated thereby. This is particularly noticeable when alternating currents are being dealt with, and an ignorance or disregard of some of the peculiar properties of alternating currents frequently gives rise to most unexpected and unpleasant phenomena.

The protection of a costly and delicate electric cable by laying it in an iron pipe is a case in point. Mechanically it leaves little to be desired; and if only continuous currents are to be carried, there is nothing to be said against the arrangement from the electrical point of view; but if the cable is used for alternating currents, a quite new set of conditions has to be taken into account. It is an elementary fact that every conductor carrying a current is surrounded by a magnetic field proportional to the current, and it is equally well known that any variation of the strength of the field will induce currents in a solid conductor or closed circuit lying within the field.

Applying these facts to the case of a cable, we see that every alternation of the current will cause a corresponding reversal of the surrounding magnetic flux, and thus currents will be induced in both the lead sheath and the iron pipe through which the flux passes. It was taken for granted that a single-core cable for alternating current would never be laid, in practice, in an iron pipe; but this case was dealt with first as typical of what occurs in a less degree in the case of two and three-core cables, in which the external field is not so pronounced.

When a single-core cable lies inside an iron pipe, the permeability of the iron will cause by far the larger proportion of the magnetic lines to be confined to the body of the pipe, although a certain number will lie both inside and outside it. With quite ordinary proportions of pipe, it will be found that with moderate currents the induction is sufficient to cause a high degree of saturation in the iron; and as the magnetization is reversed with every alternation of the current, the hysteresis losses are very considerable. With a maximum induction of only 10,000 lines per square centimeter and 50 alternations per second the hysteresis loss in a wrought-iron pipe is of the order of 1 kilowatt per cubic foot of iron.

If the pipe is of appreciable thickness, a further effect of the alternations of the current is to induce eddy currents in it, which flow longitudinally along the inner surface and return along the outer. These currents set up their own magnetic field, which opposes the main induction in the iron, so that the center of the walls of the pipe may be almost or quite unmagnetized. This has the effect of diminishing the hysteresis losses, but the ohmic losses due to the eddy currents themselves then become a serious matter. In the lead sheathing of the cable we have only to consider eddy current losses, as, of course, magnetic hysteresis does not occur. The sheathing may be regarded as made up of a number of parallel longitudinal strips, and the eddy currents will be induced along them, tending to oppose the main current. If the sheathing is perfectly insulated, the eddy currents will be confined to the surface of the lead, traveling along the inner face, and returning along the outer, and vice versa; but these currents will not be of any magnitude on account of the resistance of such a path.

On the other hand, if the ends of the sheath are earthed, the return circuit will be completed through the earth, and alternating currents will flow between the ends, spreading out to a great distance in all directions. As, however, there must be a return circuit somewhere, the earth currents to which it will give rise will, to a large extent, neutralize those of the first conductor; and, in fact, we cannot deal with the question at all unless the return circuit is taken into account, for otherwise the first conductor is tacitly assumed to form part of an infinite circuit, hence the magnetic field it sets up will be infinite, and the alternations of this field will produce an infinite electromotive force between the ends of the sheathing.

As this electromotive force opposes the main current in the cable, it is clear that no current can be produced in the cable unless the main electromotive force is of infinite magnitude, so that the whole question becomes indeterminate.

In considering a more practical case, in which the outgoing and return cables are side by side, Mr. Field pointed out that the electromotive forces produced in the lead sheaths are opposite in direction, so that if the ends of each sheath are connected to earth or to the ends of the other, a closed circuit is made in which the secondary currents can circulate.

If the three-core cable is assumed to be steel armored, or laid in an iron trough, the external field will be largely increased, perhaps to the extent of two or three times its original value; and as the losses depend upon the square of the field strength, these possible sources of loss are therefore too serious to be neglected by engineers. The best way to minimize the bad effect of an earthed copper sheath is to wind the copper strip of which it is composed with a lay as different from that of the cores as possible, and then to coat the strip with a covering of paint before putting on the lead sheath.

There will be quite sufficient resistance in the paint to prevent eddy currents passing and repassing from the copper to the lead, although in case of failure of the high-tension insulation the presence of the paint would not impair the efficiency of the earthing of the copper to any appreciable amount. An external field will also be produced by concentric cables, unless the inner is absolutely central with the outer conductor; and if two or more concentric cables are connected in parallel, any resistance, in either the outers or inners, which would cause an uneven distribution of current between them will have the same effect.

A High-Speed Electric Railway from Berlin to Hamburg

According to "The Electrical Engineer," of London, Messrs. Siemens & Halske and the Allgemeine Elektricitäts Gesellschaft, of Berlin, have prepared detailed schemes for the construction of a high-speed electric railway from Berlin to Hamburg, a distance of 180 miles. The former offer to construct the line for $17,500,000 single track, or $26,000,000 double track, guaranteeing a speed of 100 miles an hour. The Allgemeine Company is willing to guarantee a speed of 125 miles an hour, charging the same fares, though the cost of construction would probably be higher. On the basis of Messrs. Siemens & Halske's figures it is estimated that with $5 first-class fares and $3.75 second, 520,000 passengers annually would make the single line and 850,000 the double line profitable. As the German Emperor is ambitious that Germany should be the pioneer in this class of traction, it is considered rather probable that one of these schemes will be adopted. In this connection it may be noticed that Prof. von Borries, of the Technical University, Charlottenburg, in delivering a lecture on the subject of high-speed electric railways before the German Society of Engineers, expressed his conviction that steam locomotion had reached the limit of its capabilities, and prophesied its supersession by electric. He considers, however, that a speed of 95 miles an hour must suffice for the present, any higher rate entailing too great an expenditure of energy.

Large Water Power Development at Duluth

The plans of the Great Northern Power Company, Duluth, Minn., have been financed, and work on the water power development of the St. Louis River at Duluth will commence at once. This is the company proposing to equip the iron ore roads running between the Vermillion and Mesaba ranges to the head of the lake with electricity for the handling of all trains. The scheme has not been definitely settled as yet, but may be in the course of a reasonable time. The company will, however, furnish power for uses about the head of the lake, and will probably transmit power to many of the mines of the Mesaba. The initial development will be for 30,000 H. P., and it is proposed to increase this, as required, to a total of considerably more than 100,000 H. P., which is available at the rapids. These rapids have a fall of more than 500 feet. A drop of 365 feet will be had through the pipe line of the company from an open canal at the head of the cliffs to the river below. From a 70-foot dam further down the river the company will develop sufficient direct hydraulic power to permit the operation of one of the largest pulp and paper mills of the United States, negotiations for the erection of which have been in progress for some time.

Opening of the New York Rapid Transit Subway

The New York underground railway, so it is now announced, is to be opened formally on September 1. Elaborate ceremonies, in which the Mayor of New York and other city officers will take part, are to be held.

Work on the Rapid Transit Subway was begun in 1900, when to John B. McDonald was awarded the contract to construct it and maintain it for fifty years. Although it was expected that the subway would have been in operation some months ago, the contract calls for the completion of the system specified in contract No. 1 four and one-half years from the time it was signed.

The work has been held up repeatedly by strikes, which have prevented the sub-contractors from finishing their sections on time; by unlooked-for difficulties in tunnelling and excavating, and by minor accidents. Forty-second street proved the hardest nut for the contractors to crack, and the street was torn up for a longer time than any of the other thoroughfares under which the now almost completed tunnel runs.

The cost of the section which is to be formally opened on September 1 exceeds $37,750,000, the bonds of which will be retired at the end of fifty years.

The idea of an underground railway for New York had its inception in the brain of Abram S. Hewitt in the year 1888, at which time he was Mayor of the city. Mayor Hewitt's plan was not favorably received, but it was responsible for the passage of the Rapid Transit act in 1891, under which the subway plans have been carried out.

In 1894 the Rapid Transit act was amended by a clause putting the matter to a vote of the citizens of New York, who approved the plan of the city constructing the road and then leasing it to a corporation.

The Rapid Transit Commissioners, under the powers given them by the act of 1891, chose as their chief engineer William Barclay Parsons, who has had charge of the plans for the tunnel.

The Interborough Rapid Transit Company secured the lease of the road and will operate it.

New Electric Locomotives for the New York Central Railroad

New electric locomotives for use in operating the trains of the New York Central and New York, New Haven & Hartford Railroads within a radius of 50 miles of New York, are being built at the Schenectady shops of the General Electric and American Locomotive Companies.

The driving power of each will be furnished by four 600-volt direct-current gearless motors, each of 550 horse-power. This will make the normal rating of the locomotive 2200 horse-power, with a maximum rating of about 2800 horse-power, or about 50 per cent. greater than that of the largest steam passenger locomotives now in service.

The motors are bipolar, the magnetic circuit, the field windings and the motor poles being integral with the locomotive frame, and spring supported.

The locomotives will be 37 feet in length over all. The wheel base will consist of four pairs of motor wheels and two pairs of pony truck wheels, the length of the total wheel base being 27 feet, and of the rigid wheel base, consisting of four pairs of motor wheels, 13 feet. The diameter of the driving wheels will be 44 inches, and of the truck wheels 36 inches. The driving axles will be $8\frac{1}{2}$ inches in diameter. The locomotive will be a double ender, and will not require the use of a turntable.

The locomotives will be provided with all the usual accessories of a steam locomotive, including an electric air compressor to furnish air for the brakes; they will have whistles, bells and electro-pneumatic sanding devices and electric headlights at each end. The interior of the cab will also be heated by electric coils.

In actual performance these locomotives are expected to give better results than any engine hitherto placed upon rails. With a light train they are expected to give speeds up to 75 miles an hour, and with heavier trains similar speeds can be attained by coupling two locomotives together and working them as a single unit. The tractive force of 34,000 pounds will be greater than that of any passenger locomotive now in existence.

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Leading Articles

The Telephone in Railroad Service

THE increasing use of the telephone in the business of railroads was brought out clearly at the recent annual convention of Railroad Telegraph Superintendents, held at Indianapolis, Ind., to which reference is made elsewhere in this issue. Thus far the telephone is not used systematically for the moving of trains, but a decided step in this direction was made at this meeting in the appointment of a committee to bring the matter to the attention of the American Railway Association, in order that the use of the telephone in train despatching may receive the consideration, and perhaps the sanction, of that body. Up to this time the use of the telephone has not been authorized by the Railway Association for this purpose, and until it is so authorized it is not probable that the railways will generally adopt that method, inasmuch as the management of such roads are chary about adopting innovations which, in the event of accidents, might lay the company open to the charge of having employed methods of operation that had not yet received general approval.

One of the objections, and perhaps the main objection to the employment of the telephone in this work, is the difficulty of distinguishing between the sounds of some letters of the alphabet in telephonic transmission. This, it is feared, might lead to mistakes in the reception of train orders that would result in accidents. In the transmission of train orders by telegraph the words and figures of a message are spelled out, and thus errors from the cause stated are not frequent. It is, however, pointed out that on double-track roads equipped with block signals, and on which the trains run on a regular schedule, the need of train orders or train despatchers for the movement of trains is minimized.

Another example of the care taken to prevent train accidents by the misreading of train orders is shown in the precautions observed in the style of typewriter approved on railroads for use in receiving train orders. Thus, it was found that the old-style figure 8, when lightly printed, sometimes resembled the figure 3. This defect was obviated along with other somewhat similar defects by reconstructing the characters so that such errors could not occur.

An advantage of the employment of the telephone in railroading is that it frequently dispenses with the services of skilled operators, and in this way many hundreds of dollars are saved to the companies every year. One of the places where the telephone is thus used to particular advantage is at long sidings where trains may have had orders to await the passing of other trains. At such places there is now placed a telephone outfit contained in a box about 2 feet long and 1 foot wide, supported on a telegraph pole. The telephone outfit is in direct connection with the train despatcher. If there is any delay in the arrival of the expected train at this siding, the conductor of the waiting train opens the box by a special key with which he is provided and converses with the train despatcher, who may then order the train to proceed to the next siding or station, thus avoiding the delay that would otherwise have occurred.

These boxes are weather-proof, and the opening of the doors places the instrument in circuit, while the closing of the door opens the circuit, both automatically. Somewhat strange to say, although nearly all of these boxes are stationed at points remote from any police supervision, there is no case on record where any of them have been maliciously or otherwise tampered with. One explanation of this fact may be that the laws are very severe in case of tampering with railroad property, and the judges usually impose severe penalties when the perpetrators of injury to such property are brought before them.

Another plan of giving trainmen prompt telephonic communication with headquarters consists in supplying them with portable telephone outfits, to which are attached two flexible insulated wires connected with two long, light, telescoping rods, at the upper ends of which the wires terminate in metallic clamps. When, as in cases of accident, or at any other time, it is necessary for the trainmen to communicate with the train despatcher or superintendent, the clamps at the ends of the rods are connected with a certain two of the overhead wires on the adjoining pole line. By reference to blue-print diagrams of the pole line the trainman knows which wires will place him in communication with headquarters. He can then

call up the desired officer and get his orders or state his needs.

In striking contrast to the apparent indifference of the commercial telegraph companies to the inroads that the telephone is making in the railroad telegraph service is the activity of the telephone interests in furthering the introduction and in extending the use of the telephone in every possible way. To this end they have organized railroad departments for the special object of supplying railroad companies with information, technical and commercial, that may be necessary in forwarding the employment of the telephone in every branch of the railroad service. Telephone apparatus, such as desk sets, for example, is leased at a nominal figure, and privileges of inter-switching the railroad and public service are now granted, and in many other ways the favor of the railroads is sought by the telephone interests.

It was not always thus, however. Indeed, up to within a comparatively short time ago any favors that the railroad companies, in common with the general public, received from the same telephone interests were well paid for; in fact it will be understood that the allusion to nominal charges in the preceding paragraph means nominal by comparison with the charges of a former period. The present charges represent quite a fair return on the investment. But the telephone interests have seen a light. Perhaps it will dawn on the commercial telegraph companies in due time.

Electric Business Prospects in the Far East

AMERICAN electrical engineers and manufacturers have not made their influence felt as much in Russia as in Japan or Korea, and it is not likely that for the present there will be any great improvement in this respect; but Siberia and Manchuria eventually must prove a field for electrical development that will attract a good deal of attention. German electrical engineers and manufacturers have made more headway in Siberian Russia and Manchuria than any other of the Europeans, and from Omsk to Vladivostok there are electrical stations equipped with machinery and motors of German design and make. Vladivostok and Port Arthur were rapidly becoming the most important centers for electrical development in Russia's far eastern domain, and there were upward of half a hundred firms in each city directly interested in electrical supplies of some kind. Dutch and German dealers in electrical supplies had built up a good business in each of these places.

The question of what effect the war between Russia and Japan will have on the electrical trade in the Far East is one that is intimately appealing to numbers of manufacturers and exporters of electrical equipments in this country. Should Port Arthur, Korea and Manchuria be "Japanized," the effect would undoubtedly prove beneficial to this country, for the Japanese have always favored American electrical products. A good many Japanese engineers were educated in American technical colleges, and it is only natural that they should favor the electrical products of the design with which they are most familiar. The slight beginning made in Korea by American firms should likewise open up that country to still further usefulness in this respect.

Manchuria and Siberia are vast uncultivated fields for electrical exploitation that must soon enter largely into economic questions of the Far East. Electric light and power plants are distributed along the line of the trans-Siberian railroad. At Harbin and Mukden there are electric power and manufacturing plants which the Russian forces are now utilizing for their purposes. At Tomsk, Omsk, Irkutsk and Ctretensk central stations are located which supply current for manufacturing and lighting purposes. Most of these were installed and equipped by firms from central or European-Russia; but on the whole there has been little attempt to develop Siberian trade. This has languished, and yet in a climate such as that country has, electricity is of the utmost importance.

Most of the Siberian power plants, whether operated by steam or electricity, use liquid fuel. Oil is carried from the Baku-Batoum district to the towns and cities on the line of the trans-Siberian railroad, and is stored at convenient places. It is the most convenient fuel to transport, and the coal mines have not yet reached a state of development to enter actively in competition with oil in the regions where this fuel is plentiful. The water-power of Siberia and European-Russia is seriously handicapped by the climate. For six or seven months in the year ice would make even the rapids of the Volga and Neva difficult to utilize for generating electric power, though in the few summer and spring months it might be ample for even large demands.

Russians are slow to impart information concerning their work or plans for the future. There is universal suspicion, and everyone is close mouthed. The owner of an electric plant is never ready to answer simple engineering questions put with no ulterior purpose other than that of seeking scientific information. Russia is a country that needs development, and it is the one that least favors those foreigners who are seeking to spend money in opening up new industries.

This was made apparent in the Baku oil districts when American capital sought to develop the industry. There was universal opposition to the establishment of pipe lines, and later when American engineers undertook to establish long-distance electric transmission, using the oil fuel for developing power, and running the lines to adjacent mining and manufacturing districts, they were discouraged on every side. It is the Russian fear of foreigners securing rights and control of resources which in time they might need and want to develop themselves.

The electrical engineer in Russia or Siberia is a poorly paid functionary, and central station mechanics and electricians are on as low a plane as telegraph operators. None of these are paid wages that have an equivalent purchasing power in American money of more than $25 to $35 per month. The grade of the workers is naturally inferior, and there is little opportunity for foreigners ever to shine in this line. Even the station and factory superintendents receive pay that would discourage Americans. The days are long, the work is oftentimes arduous, the climate cold and uncongenial and the outlook generally unsatisfactory.

And yet the Russian character is one that has its admirable qualities, and in time the Slav race may excel in electrical and engineering work. The great resources of the country today offer such a fair field for the development of iron, steel, coal and electrical industries, with all others dependent upon them for their life, that foreigners grow impatient at the indifference of the natives. Germans, Austrians, Belgians and the French have made some headway in opening up these industries in Siberia; but the English and Americans have practically little foothold. The stations at present established are equipped with boilers, engines, turbines and generators bearing marks of the best European makers.

Electricity for power and for lighting has certainly become a permanent factor in the development of Siberia along the line of the trans-Siberian railroad, and it is gradually developing the resources of Manchuria. This latter province, as well as the rest of China, Korea and Japan, will be the great industrial battle-ground for the

future. Whatever the result of the present war may be, conditions will be changed. Russia, seeing the great advantage obtained by Japan through her adoption of modern improvements, will awaken, and if she retains her far eastern possessions she will probably admit competition more generally. If Japan's influence predominates, there will be little question about the opportunities of America in building up trade.

The engineering problems, both electrical and others, which press for solution in Siberia and Manchuria are of the most difficult and intricate. The climate, resources and natural conditions of the country offer a field which calls for the highest talent. Telegraph and telephone lines run across the most barren country of the world, and in winter they are most difficult of construction and maintenance. Electric lines cannot be constructed and maintained without protective equipment scarcely known in any other land. Insulating material must be provided that will not crack or warp when the mercury is 30 or 50 degrees below zero, and at the same time it must possess sufficient elasticity to retain its normal conditions in hot summer weather. This has been a difficult electrical problem in Northern Siberia and Manchuria. A good deal of the material used for wires has cracked and split in the extreme winters. Some American insulating material used at Tomsk and Omsk has withstood the test better than anything made in Germany or France. This simple fact may eventually prove the entering wedge that will induce the Russians to try other American supplies as well.

A study of electrical conditions in Siberia and Manchuria shows that there is much for the natives to learn and adopt before their resources can be brought up to a par with those of the smallest of European nations. European-Russia has been in closer contact with the continental countries and the different establishments there have reached a much higher level in their work; but Siberia is a great undeveloped country that has been neglected. Its invasion must come from the far eastern side, passing through Manchuria and along the line of the Siberian railroad. It is a realization of this fact that makes the present war such an important one from a commercial point of view.

Eventually Japan may prove a commercial power that may strongly compete with Europeans and Americans, but it is not yet prepared to offer electrical equipments likely to be formidable. Indeed, Japan is a great market for American electrical products, and her engineers are among the most progressive in the world. Their adoption of the best in the manufacturing world has proved of the greatest value to them in the present war, and it probably illustrates the national mind better than anything else.

Gas for illumination has made little progress in the Far East. The kerosene oil lamp serves in the country districts, but in the towns and cities something better is demanded. Electricity has there proved the most efficient and satisfactory of all lighting methods. Whether electric manufacturing and electric railways will, however, prove as popular in the next few years as they have in the near past, is a question that cannot be easily answered; but the success of the American electric railway in Seoul, Korea, argues favorably that in time this method of rapid transit will become well established in Siberia, Manchuria, China and Japan.

Electrical technical literature is as scarce in these far eastern countries as popular fiction, and this is practically non-existent. No periodicals are published there and few foreign publications find their way into the country beyond the few seaport towns. Under such conditions the development of engineering industries appears handicapped.

Preventing Pole Line Collapses

MANY suggestions have been offered to prevent the wholesale collapse of telegraph, telephone and transmission lines during blizzards, or on the occasion of sleet or wind storms, but not all have been successful in practice and some are impracticable. One method recently referred to in these pages, namely, the bracing of poles for electric transmission by means of head guys from one pole to another, has been tried and found wanting, while parallel pole lines protected by side guys had remained standing under similar conditions.

The use of two poles side by side and braced against each other, with the cross-arms supported between them, has been frequently advocated, but has not been put into practice in this country. On a section of telegraph line along the Lackawanna Railroad, about 21 miles in length, on the plateau of the Pocono Mountains, 2000 feet high, a great deal of trouble has been occasioned by the sleet-storms and high winds that frequent that locality in the winter season. The line had 50 poles to the mile and carried 24 telegraph and telephone wires on four cross-arms. It was decided to test the efficacy of doubling the number of poles to the mile, which was done, with the result that during the past two winters the wires have stood up continuously. In fact, there has not even been a "swing" or "cross" reported on the section in question since the change referred to was made, the short span between the poles preventing the wires from swaying sufficiently to come together.

The only objections that can be offered to this plan of overcoming the difficulty mentioned are first cost and possible diminished insulation resistance of the wires, owing to the added poles and cross-arms. The first cost feature may be dismissed, as the expense of repairing the line after one severe collapse is fully equal to its original cost. The decreased insulation resistance in the case cited would at most be equal only to increasing the total length of the circuits by 21 miles, an amount which is insignificant in telegraph practice. The tendency, however, in the case of transmission lines has been toward heavy poles or towers at much greater distance apart than formerly.

The doubling of the number of poles on this section of the popular "road of anthracite" has more than once had the effect of procuring for the road an enviable reputation for high speed and smooth traveling, in the following way:—Statistics usually allow 45 to 50 telegraph poles to the mile, and it is a common practice for people of a mathematical bent to calculate by the aid of a stop watch and the number of poles passed in a given time, the speed of the train. Seeing the poles passing, or seemingly passing like a picket fence at the point in question, the usual calculation is made, with the result that it is discovered that the train is apparently traveling at the rate of 95 to 100 miles per hour, and the mathematician announces this speed as an accurate record to his friends in due course.

Through the agency of a direct telephone service Rev. Dr. Russell H. Conwell recently preached to all the patients in the Samaritan Hospital in Philadelphia and at the same time to an audience that filled the auditorium of the Baptist Temple. More than fifty patients, in the various wards of the hospital, with telephone receivers at their ears, heard Dr. Conwell tell his audience in the Temple, nearly 2 miles away, of the developments in science, art, literature and religion that have been born of sickness. The telephone connection with the hospital will be improved and made permanent.

THE PALACE OF ELECTRICITY IS THE MOST PERFECTLY ILLUMINATED BUILDING ON THE EXPOSITION GROUNDS

Illumination at the St. Louis Exposition

The Incandescent Lamp in Decorative Service

By A STAFF CORRESPONDENT

THE great expositions that have occurred at frequent intervals during the past quarter century, marking like mile-stones the epochs of the world's activities, have each surpassed the preceding ones in almost every particular.

The merits of every phase of such expositions are passed upon by comparison with previous efforts in the same line, and thus it is that the visitor to the St. Louis Exposition finds an expression of merit only in terms of the impression produced by some other exposition he has visited.

The aim of the directors of the St. Louis enterprise has been, from the first, to surpass in every particular the marks set by the wonderful White City at Chicago in 1893, the Paris Exposition in 1900, and the small, but beautiful creation at Buffalo in 1902, the electrical features of which were, at that time, the most brilliant ever produced. That this might be done, the best available men were picked to fill the various executive positions, and the selection of Henry Rustin as chief electrical engineer was but an acknowledgement of his eminently successful work at Buffalo, where, with limited means, splendid effects were produced.

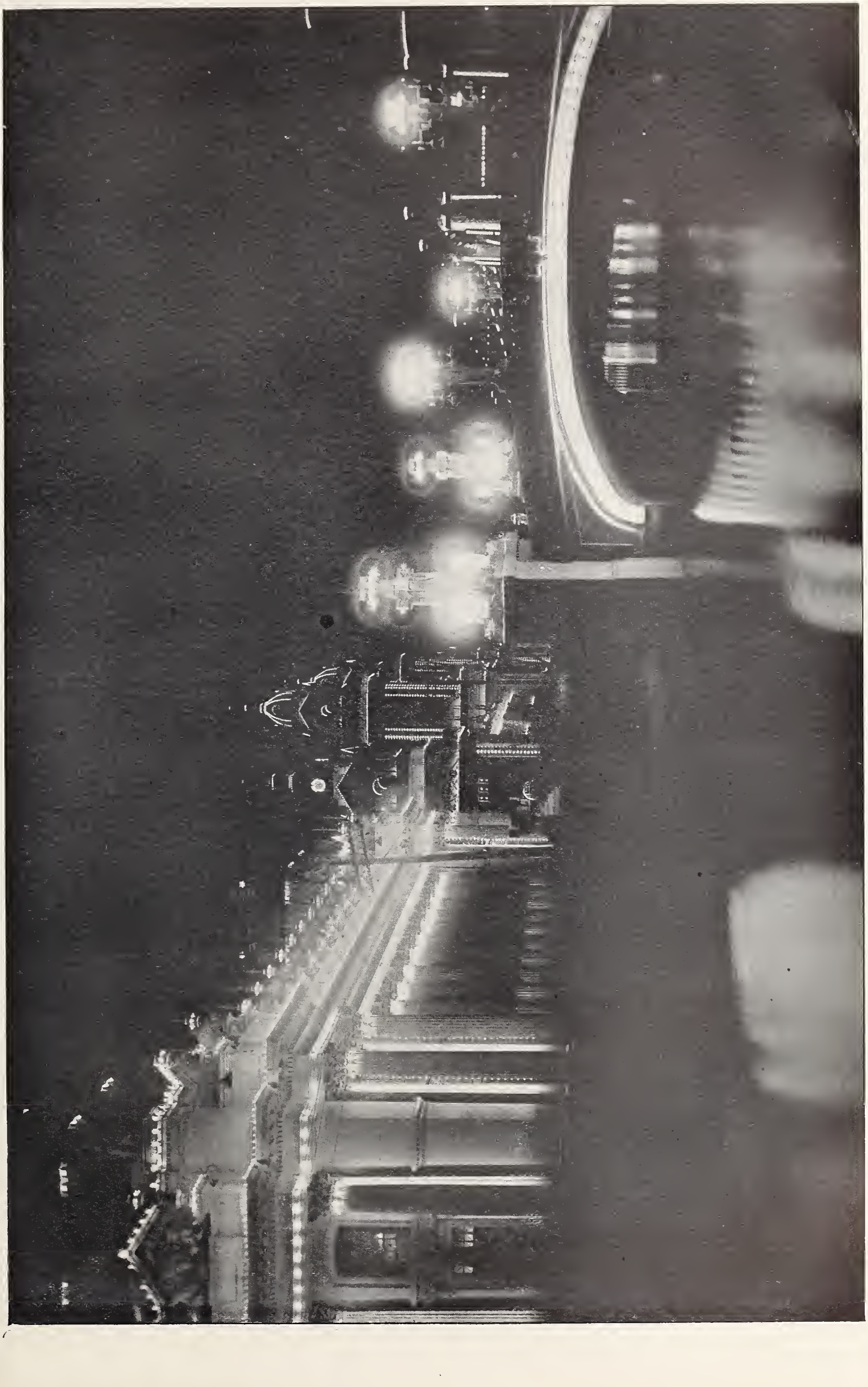
When Mr. Rustin assumed his duties at St. Louis, he found a problem confronting him that was not, with all his experience in exposition work, capable of rapid or easy solution. The main buildings of the exposition are grouped on avenues that radiate from a common center, composing what is termed the "main picture," and naturally the architecture of each building differs widely from that ot the others. The whole being under the censorship of the director of works, harmony was assured on that point; but when one man is called on to conceive and work out the illumination of a group of such buildings, and have it in keeping with the architectural expression of each designer, and at the same time blend all into a harmonious whole, the complexity of the problem becomes apparent.

At the focus of the fan-shaped arrangement of the main avenues of the exposition is located Festival Hall, a circular building surmounted by a dome, the structure standing on an elevation of nearly a hundred feet. To the right and left, forming almost a semi-circle, are colonnades, terminating in smaller circular buildings, immediately in front of which are the auxiliary cascades. The main cascade, the great electro-aquatic feature of the exposition, begins its plunge high up in front of the main doorway of Festival Hall. The water appears to come from the heart of a gigantic shell, the opening of which is over 10 feet across, falls, in a sheet nearly a foot thick, into a basin immediately beneath, and from this into a succession of ever widening spills, finally reaching the Grand Basin in a sheet nearly 200 feet long.

The original idea contemplated the use of Cooper-Hewitt lamps placed under the spills, the effect sought being to transform the falling sheet of water into a phosphorescent mass, but, as it was found impracticable to make use of the mercury vapor lamps in this manner, incandescent lamps of an emerald hue were substituted, and the result is most satisfactory. The water being in quantity great enough to destroy the identity of the individual points of light, the entire body of water assumes an emerald color, which is retained until the water reaches the level of the Grand Basin.

A departure from all previous methods of illumination has been worked out by Mr. Rustin, and although but a few tests have been made, these serve to indicate the gorgeous effect that will accompany the com-

A BRILLIANT NIGHT EFFECT. ANOTHER VIEW OF THE PALACE OF ELECTRICITY. TWELVE THOUSAND INCANDESCENT LAMPS ARE USED IN ITS ILLUMINATION



ON THE GRAND BASIN

THE VARIED INDUSTRIES BUILDING

pletion of this feature. Briefly, the scheme consists in having a triple socket in place of the single socket ordinarily used, each one to contain lamps colored emerald, amethyst and yellow. These sockets are installed only on the columns constituting a part of the Terrace of States, and are connected to a balanced three-phase system, with a common neutral; that is, the lamps of each color are balanced, and are under the separate control of the operator. With these three colors under rheostatic control, the number of combinations is almost endless, and the effects can be realized only when seen.

The cascades being the main feature of the exposition's day picture, it was natural that Mr. Rustin should concentrate his efforts to make them the "pièce de resistance" at night, and, although many difficulties have been encountered, they have almost without exception been overcome. Pictures give but a faint conception of the magnificence of the illumination.

Current is generated in the power plants in Machinery Hall, the load being assumed by a 5000-H. P. Allis-Chalmers-Bullock unit and four Westinghouse 2000-K. W. units, these latter constituting the Exposition Power Plant, the former being one of the units of the Exhibitor's Power Plant. Steam for the engines is furnished by a collection of boilers of various makes, installed in the Steam, Gas and Fuel Building, just west of Machinery Hall. These installations represent the most modern practice in every respect, and, taken collectively, constitute the largest temporary power plant ever erected. The illumination of the exhibit buildings, together with the power load, averages about ten thousand horse-power, about nine thousand horse-power being utilized for lighting alone.

The current is generated at 6600 volts, and is distributed through subway and conduits to the various substations, located in each of the exhibit palaces and at other load centers, at which points it is stepped down to 110 volts. The feeders from the sub-stations are arranged in sections, each quarter of the building being under the control of a separate switch, and the final division takes places in wooden cabinets located at the proper electrical points. The construction, while representing economy in every detail, has been carefully carried out, and has, up to the present time, given almost no trouble. All of the feeders are carried in cleats, and knobs are used for the smaller wire.

The lamps are of eight-candle-power, and are placed on 15-inch centers, with the exception of those on the dome of Festival Hall, where a much closer spacing is used. The candle power and the spacing of the lamps were adopted as the result of careful photometric tests and the experience of previous installations of similar character, the intention being to carry out the architectural idea in a soft and pleasing manner, avoiding concentration of light at any particular point, except in rare cases. With the same end in view, the lighting was confined to incandescent lamps, no arc lamps being used except in remote portions of the grounds, where they do not enter largely into the lighting scheme. It is interesting to note that the low frequency of 25 cycles is not noticeable, except, perhaps, to the trained eye, although considerable comment resulted from the announcement that this would be used.

As might be expected, the Palace of Electricity is the most brilliant, and the most perfectly illuminated building on the grounds, its cornice and roof lines being marked by thousands of lamps, placed in the Greek honeysuckle ornaments that follow those lines. The effect is that of a fairy palace, and is quite unlike that with the straight rows of lamps found on the other buildings. All told, over twelve thousand lamps were required

LOOKING DOWN ONE OF THE WATERWAYS IN THE ST. LOUIS EXPOSITION GROUNDS

to fill the sockets on this building, and approximately two hundred and fifty thousand were required for the entire installation.

The most attractive glimpses of the exposition at night have been reproduced in several illustrations accompanying this article and in the double-page supplement plate.

The International Electric Congress at St. Louis

A NUMBER of national electrical bodies have already arranged to co-operate in the Internatioal Electrical Congress, to be held at St. Louis in September. In America a number of these co-operating bodies are to hold simultaneous conventions in St. Louis during the Congress week, and to hold joint sessions with specified sections of the Congress on definitely appointed days. Other bodies are not going so far as to hold simultaneous conventions and joint sessions, but have accepted their invitations to send delegates to the Congress. Invitations to send delegates have been forwarded to thirty national electrical and scientific bodies all over the world, and the following ones have already promised to hold simultaneous conventions and joint sessions:—The American Institute of Electrical Engineers, the American Electrochemical Society, the American Physical Society, the International Association of Municipal Electricians, and the American Electrotherapeutic Association. Delegates will be sent to the Congress by the National Electric Light Association and the Association of Edison Illuminating Companies.

European delegates will come from the Société Internationale des Electriciens and the Sweizerischer Elektrotechnischer Verein.

It is expected that the Institution of Electrical Engineers of Great Britain, and the Electrotechnischer Verein, of Berlin, will also send delegates.

It is hoped that other European national electrical bodies will also cooperate. The delegates accredited to the Congress from various co-operating bodies are not expected to be called upon to vote upon any questions of national importance. All matters concerning units, standards, etc., will lie within the province of the Chamber of Government delegates.

All delegates of the co-operating bodies are invited to read papers before any section of the Congress they select. Such papers will be printed in the Congress transactions as being offered by the delegate on behalf of the co-operating body. The paper and discussion thereon will subsequently be offered by the Congress to the co-operating body for incorporation in its own transactions, if desired.

The delegates of the American Institute of Electrical Engineers and their papers to the Congress are Mr.

Ralph D. Mershon, who will read a paper on "The Maximum Distance to which Power can be Economically Transmitted"; Professor M. I. Pupin, who will have a paper on "Electric Impulses and Multiple Oscillators"; and Professor C. P. Steinmetz, who will discuss "The Theory of the Single-Phase Motor."

The delegates of the Electrochemical Society and their papers will be Prof. W. D. Bancroft, "The Chemistry of Electroplating"; Prof. H. S. Carhart (with Dr. G. A. Hulett), "The Preparation of Materials for Standard Cells and their Construction"; and Prof. L. Kahlenberg, "The Electrochemical Series of the Metals."

The delegates of the National Electric Light Association and their papers to the Congress will be Mr. Geo. Eastman, "Protection and Control of Large, High-Tension Distributing Systems"; Mr. G. Ross Green, "American Meter Practice"; and Dr. F. A. C. Perrine, "American Practice in High-Tension Line Construction and Operation."

The delegates of the Association of Edison Illuminating Companies and their papers to the Congress will be Mr. W. C. L. Eglin, "Rotary Converters and Motor Generators in Connection with the Transformation of High-Tension Alternating Current to Low-Tension Direct Current"; Mr. L. A. Ferguson, "Underground Electrical Construction"; and Mr. Gerhard Goettling, "Storage Batteries as an Adjunct to Station Equipment." The delegates and papers of the other co-operating bodies have not yet been decided upon.

In response to invitation, the following foreign Governments have appointed delegates:—

Switzerland—Prof. Ferdinand Weber, Prof. Francois Louis Schule.

Norway and Sweden—Prof. G. Arrhenius.

India—Mr. J. C. Shields.

Mexico—Mr. Rafael R. Arizpe.

The appointments from Great Britain, France, Germany, Austria-Hungary, United States, Belgium, Italy, Denmark, Spain, Portugal, Australia, Japan, China, Brazil, Chili and Peru have not yet been made.

The following are the programmes of papers promised for sections F and G. Similar programmes of Sections A, B, C, D and E have already been published:—

Section F. Electric Transportation—Chairman, Dr. Louis Duncan; secretary, Mr. H. A. Armstrong; Ernst Danielson, "Theory of Compensated Repulsion Motor"; Philip Dawson, Esq., "Electrification of British Railways"; Herr F. J. Eichberg, "Single-Phase Electric Railways"; Prof. Dr. F. Niethammer, "Alternating vs. Direct Current Traction"; Prof. Dr. Rasch, "The Puffer Machine in Railway Service and its most Suitable Control"; A. H. Armstrong, "The Electrification of Steam Lines"; B. J. Arnold, "Electric Railways"; Louis Duncan, "General Review of Railway Work"; J. B. Entz, "The Storage Battery in Electric Railway Service"; C. O. Mailloux, to be announced; E. H. McHenry, "Some Qualifications of Electric Railway Equipment for Trunk Lines;" R. A. Parke, "Braking High-Speed Trains"; W. B. Potter, "Electric Railways"; F. J. Sprague, "The History and Development of the Electric Railway"; L. B. Stillwell, "Notes on the Electrical Equipment of the Wilkesbarre & Hazleton Railway Company"; H. G. Stott, "Central Station Economics and Operation"; W. J. Wilgus, "Equipping the Central Terminal."

Section G. Electric Communication—Chairman, Mr. F. W. Jones; secretary, Mr. B. Gherardi; Senor Don Julio Cevera Baviera, "Electric Communications in Spain"; Dr. J. A. Fleming, F.R.S., "The Present State of Wireless Telegraphy"; John Hesketh, "A New Danger to Lead-Covered Aerial Telephone Cables"; Herr Joseph Hollos, "Simultaneous Telegraphy and Telephony"; Saitaro Oi, "Telephony and Telegraphy in Japan"; V. Poulsen, "System for Producing Continuous Electrical Oscillations"; G. de la Touanne, "Questions Connected with Rates and Management in a Telephone Exchange"; J. C. Barclay, "Printing Telegraph Systems"; Dr. Albert C. Crehore, "Rapid Telegraphy"; Dr. Lee De Forest, "Wireless Telegraph Receivers"; Patrick P. Delany, "Rapid Telegraphy"; Hammond V. Hayes, "Telephony"; Franz J. Dommerque, "The Telephone Problem in Large Cities"; Reginald A. Fessenden, "Wireless Telegraphy"; J. C. Kelsey, "Features of Two-Strand Common Battery Systems"; Kempster B. Miller, "Problem. Automatic vs. Manual Telephone Exchange"; F. A. Pickernell, "Telephony"; Louis M. Potts, "Printing Telegraphy"; Col. Samuel Beber, "Military Use of the Telephone, Telegraph and Cable"; Prof. George F. Sever, "Electrolysis of Underground Conductors"; L. W. Stanton, "Economical Features in Modern Telephone Engineering"; John Stone, "The Theory of Wireless Telegraphy."

Over 150 papers had been promised up to June 23. Twelve of these have already been delivered. Arrangements are now being completed for printing papers in advance of the Congress, so that all that are received in sufficient time will be ready for circulation among the Congress members at St. Louis. Efforts are being made to secure as many of the promised papers as possible in advance.

An Unusual Electric Accident

THE accidental electrocution of two surveyors at Bingham, Utah, a short time ago, is described in "The Engineering and Mining Journal" of recent date. The two men, Adolph Jessen and Hugh Allred, were engaged in running a line for a placer claim on the hillside above Bingham Canon. Nearly at right angles to the line were strung the wires of the Telluride Power Company, which supply the town of Bingham with light and power. At the time of the accident Mr. Jessen was standing on the hillside, his feet being about on a level with the wire. Mr. Allred was below the wire, his head being lower than Mr. Jessen's feet. The steel tape was stretched on the ground between them. In some manner it became fastened in a clump of bushes near the wire, and in attempting to loosen the tape Mr. Jessen gave it a jerk. Instantly the tape rose from the bushes, and came in contact with the electric power wire. There was a bright flash at the point of contact, the two men's bodies forming a short circuit. Mr. Jessen received a sufficient amount of the 5000 voltage to cause instant death, although he stood on a rock. Mr. Allred, who stood upon wet ground, received the majority of the voltage.

Several persons were near the scene when the accident occurred and medical aid was soon secured, but it was of no avail. Except for a few burns on the hands and feet the bodies of the victims showed no marks of injuries.

For two or three years the electric light has been employed with satisfactory results for illuminating the carriages of the Western Australian Government Railways. The system is gradually being extended to all the rolling stock, and, as a consequence, the annual cost of upkeep is decreasing proportionately. The report of the acting general manager of the railways of west Australia for the last year shows that altogether some seventy carriages have been equipped, and, on the average, forty-seven and one-half were maintained for the full twelve months. The cost of upkeep is stated to be, on an average, $94 per car, as compared with $103 per car for the preceding year.

Transformers for Long-Distance Power Transmission

By J. S. PECK

Reprinted from the Electric Power Number of "Cassier's Magazine."

IN the fall of 1892 the first long-distance plant in America was installed in California for transmitting power from a waterfall on the San Antonio Creek to the cities of Pomona and San Bernardino. The transmission was at 10,000 volts, and the maximum distance of transmission 28 miles, the current being used almost entirely for incandescent and arc lighting..

For stepping-up the low voltage of the generator to the pressure required for transmission, twenty 5-K. W. transformers were used. Each transformer was wound for 500 volts, and the line pressure was obtained by connecting the twenty transformers in series. Similar arrangements of transformers were used for stepping-down the line voltage to values suitable for use in the cities.

At the time the Pomona transformers were designed, little was known regarding the construction of high-voltage apparatus, and the perplexities and difficulties encountered in the design and manufacture of these transformers can scarcely be appreciated by the engineer of to-day. The care with which the designs were worked out is shown, however, not only by the long and continued service rendered by these transformers, but by the fact that two of their most important features, namely, oil insulation and the "shell" type of construction, are retained in the most improved designs of to-day.

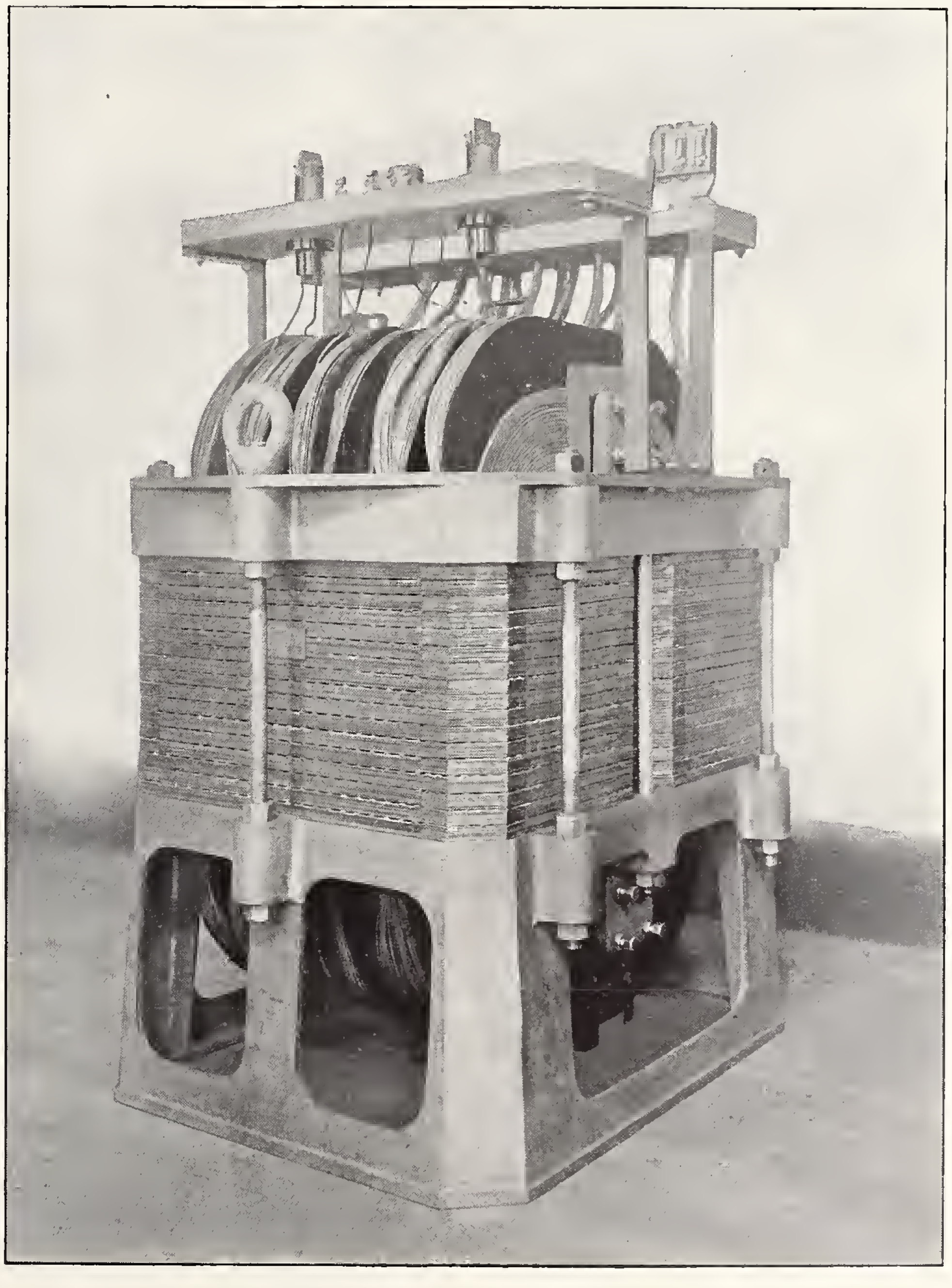
OUTPUT OF HIGH-VOLTAGE TRANSFORMERS FROM 1892 TO 1903

YEAR	Number of Transformers	Output K. W.	Maximum Voltage	Maximum Capacity K. W.	Average Voltage	Average Capacity K. W.
1892	65	406	10,000	10	9,070	6 25
1893	19	272	3,000	18.75	2.500	14.4
1894	68	1,720	10,000	100	3,600	25.3
1895	78	4,215	10,000	200	7,000	54.0
1896	150	12.820	15,000	750	9,620	85.0
1897	165	21,091	30,000	850	10,600	128.0
1898	387	49.719	30,000	500	15,300	129.0
1899	662	119.492	33,000	1,875	12,800	180.0
1900	492	171,646	50,000	2,750	17,000	350.0
1901	997	201,475	50.000	1,000	12.400	202.0
1902	985	248,982	50,000	2,200	16.700	253.00
Total	4,068	831,838	......	.....	......	204.

When this article was prepared the transformer data for the year 1903 were not available.

The success of the Pomona plant, followed closely by the introduction of the alternating-current motor, gave a great impetus to long-distance transmission work, and in a short time power transmissions were being projected everywhere. For the increased distances of transmission it soon became apparant that much higher voltages would be required than were used at Pomona. Improved manufacturing facilities and increased experience in designing made possible the construction of large transformer units wound for the full line voltage, and as a large unit could be manufactured for less cost per K. W. than a small one, the series arrangement of many small transformers was superseded by an arrangement of large units, wound for the full line voltage.

The enormous increase in the transformer business which has followed the installation of the Pomona plant, and the rapid advance in voltage and in size of transformer unit, are clearly



A 950-K. W., 50,000-VOLT WATER-COOLED TRANSFORMER. NOTE THE SIZE AND THICKNESS OF THE INSULATING BARRIERS BETWEEN THE HIGH AND THE LOW-TENSION COILS

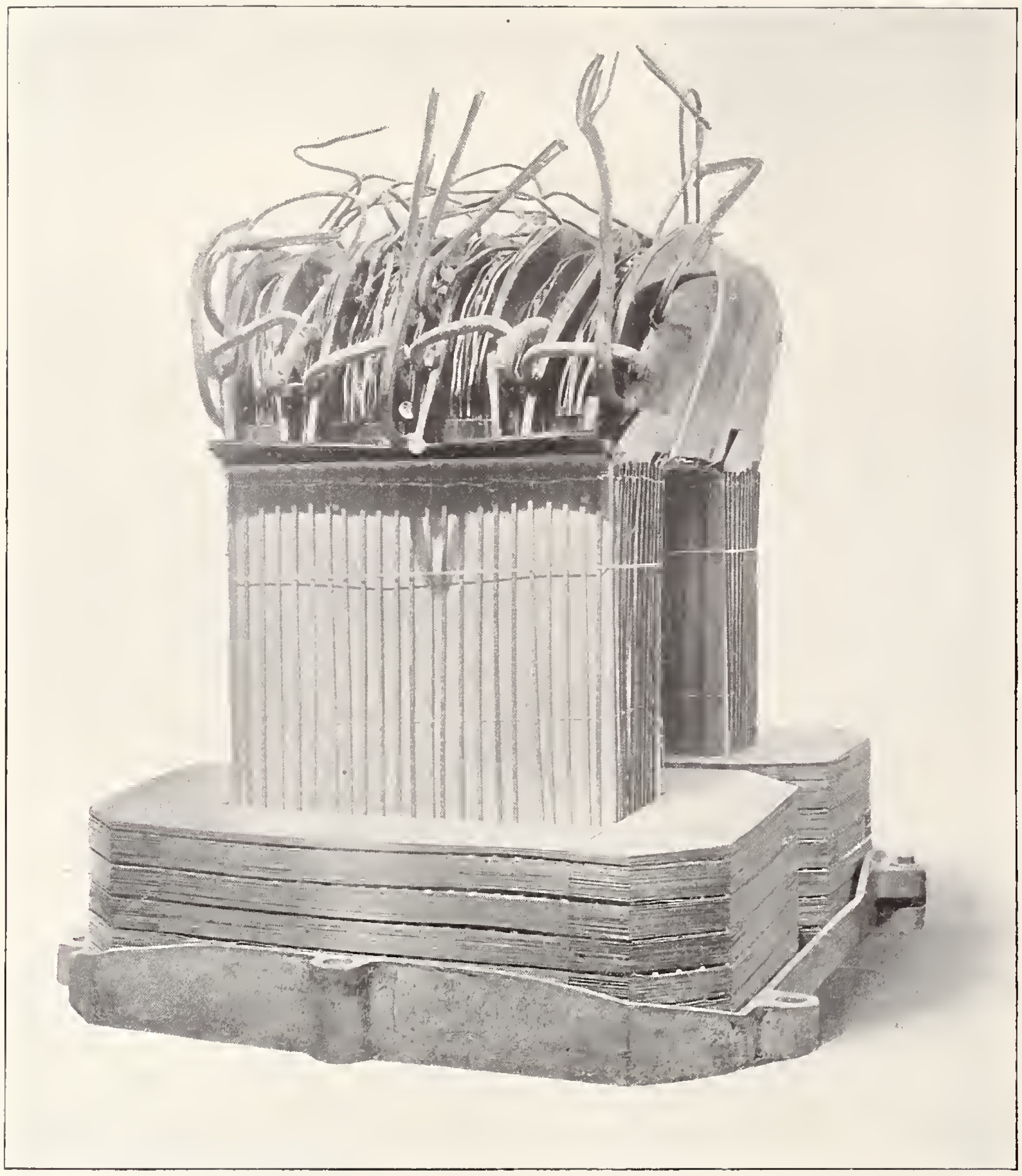
shown in the table on page 403, which is made up from the records of one of the largest electrical manufacturing companies. The transformers included in this list are all used for high-voltage transmission, and it is of interest to note that the 4000 transformers represent an aggregate capacity of 800,000 K. W.—over 1,000,000 H. P. —the average size of unit being 200 K. W.

A history of the ten-year development of the high-voltage transformer would show a most interesting process of evolution; but it is the modern transformer with which the practical engineer is most deeply concerned, and interesting as the history of this development would be, it is thought that a description of the transformer of today will be of greater value to the engineer.

High-voltage transformers may be divided into three classes:

1. Oil-insulated, self-cooling.
2. Oil-insulated, water-cooled.
3. Air-blast.

The general form of internal construction is the same in the three classes, but suitable modifications are made to accommodate the different insulating and cooling mediums. The transformer windings are composed of a number of thin, flat coils placed side by side and separated by insulating material. The coils are made up of cotton-insulated rectangular wire, wound usually with but one turn per layer. After winding they are dried in a vacuum oven at a comparatively high temperature to abstract all the moisture, and are then treated with a compound which prevents the re-entrance of moisture and adds greatly to their mechanical strength. The treating process is repeated several times to insure a heavy, uniform waterproof coating, and after this treatment the coils are wrapped with insulating material and assembled with suitable ventilating ducts and insulating barriers between them. The ventilating ducts permit the cooling medium, oil or air, to come into close proximity to all parts of the winding and thus prevent undue local heating.



METHOD OF BUILDING UP THE SHEET STEEL CORE OF A LARGE TRANSFORMER

By winding the coils with but one turn per layer, every turn may be isolated from every other one and insulated to any extent desired. This form of coil-winding is of great value in high-tension transformers, as it has been found in practice that excessive voltages may be concentrated upon a few turns of one coil, and a break between turns is fatal to the whole transformer.

The sub-division of the coils permits the interlacing of primary and secondary windings, an arrangement essential to close regulation, especially when inductive loads, such as motors or arc lamps, are supplied. It is also possible where the coils are thus subdivided to arrange the primary and secondary in two or more parts, which may be connected in series or multiple for different voltages.

While the proper proportioning of the active elements (coils of copper and core of sheet steel) is one of the essentials in transformer design, the proper selection, treatment and arrangement of the insulating material requires even greater skill and wider knowledge than does the proportioning of copper and sheet steel. This is due, in part, to the fact that copper and steel are strong mechanically, are good conductors of heat, and are uniform in their electrical characteristics. Insulating materials, on the other hand, are weak mechanically, are poor conductors of heat, and their electrical characteristics are subject to the widest variation, due to slight differences in their physical condition. Wood, for example, when perfectly dry, is an excellent insulator; but when damp or imperfectly cured, it becomes a conductor, and cases have been known where a certain voltage has broken through a thickness of several feet of green wood, while an inch thickness of the same material, properly cured, has successfully withstood the same pressure.

Almost all insulating materials are subject to similar variations in insulation strength, and the greatest care is required in their preparation as well as in the prevention of deterioration which would be caused by the absorption of moisture or other conducting material during manufacture or installation.

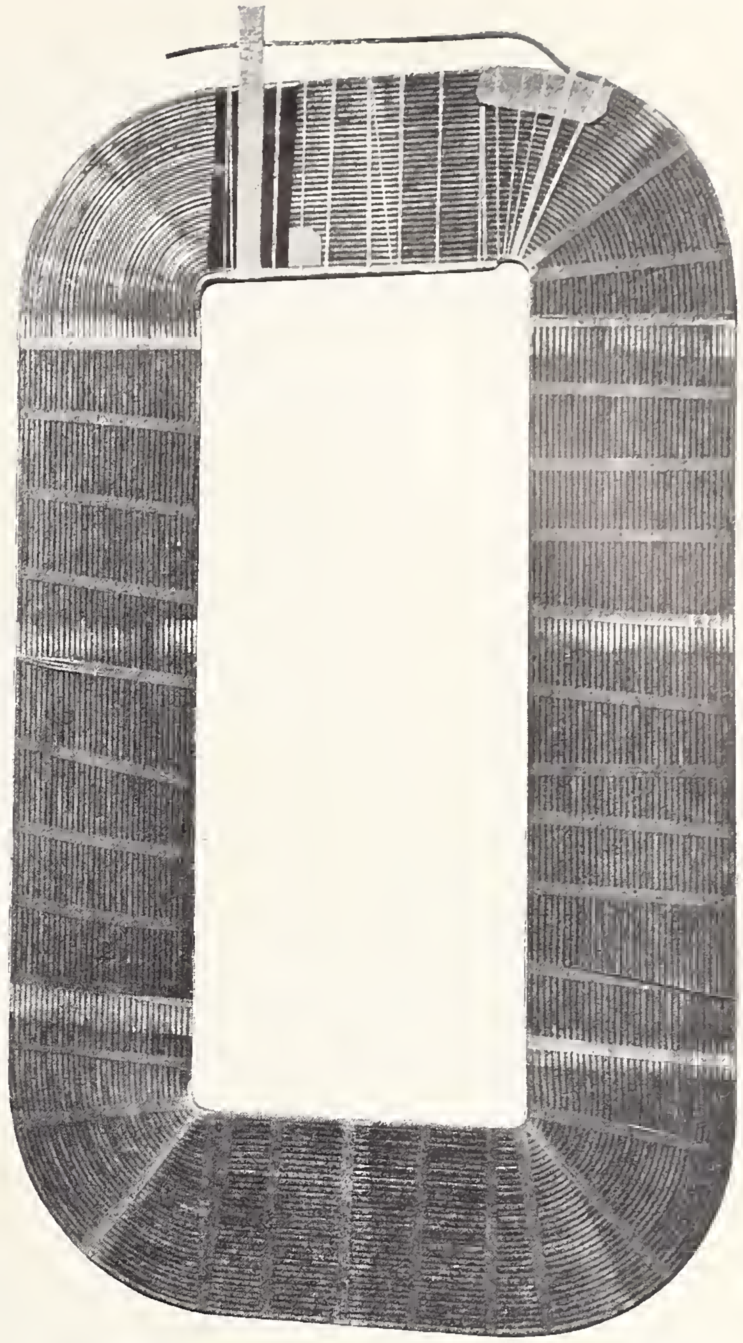
After the coils have been assembled and properly insulated, the sheet iron core is built up by hand about the coils and ventilating ducts are provided at frequent intervals throughout the structure, serving to maintain it at a uniform temperature. When the laminations are all in place, the end castings are put on and the core is bolted up solidly. The necessary terminal blocks are next secured in place, the coil leads connected to the proper terminals, and the construction of the transformer is complete. In the air-blast type of construction the castings

which hold the laminations form the case or housing, and no other covering is required; but in the oil-insulated types an outside case is necessary for holding the oil.

The losses in a transformer are of two kinds, the copper loss, due to the passage of current through the coils, and the iron loss, caused by the reversing of the magnetic flux through the core. These losses appear as heat, and suitable precautions must be taken for the disposal of this heat. In a 500-K. W. transformer having an efficiency of $98\frac{1}{2}$ per cent, there is a loss of $7\frac{1}{2}$ K. W. (10 H. P.), which is equivalent to the heat liberated by 150 16-candle-power lamps. If the apparatus is not suitably ventilated or provision is not made for carrying away this heat the insulating material will be rapidly carbonized and the transformer soon destroyed. Two general methods are in use for disposing of this heat. One is to force a blast of air through the transformer; the other is to immerse the transformer in oil, then cool the oil by means of a case provided with large radiating surface, or by circulating water through coils immersed in the oil.

In the transformer the function of oil is to insulate and to cool. As an insulator, the oil has a strength several times that of air, and is of particular value for the insulation of exposed surfaces which in air under very high voltage strains act almost as conductors. The fluidity of the oil also gives it an advantage over solid insulating material, in that it is self-healing and has the same insulation strength after a discharge as before. It is also of value for sealing in cracks or openings which may be left in the solid insulating material.

As a cooling medium, oil acts as a conveyor of heat rather than as a conductor. Coming in contact with the active parts of the transformer it is heated, rises to the top, flows over the sides, and, coming in contact with the cooling surfaces, sinks and rises again past the heated surfaces. Thus a rapid circulation is automatically established, and the heat is conveyed from the active parts of the transformer to the surfaces provided for its dissipation.



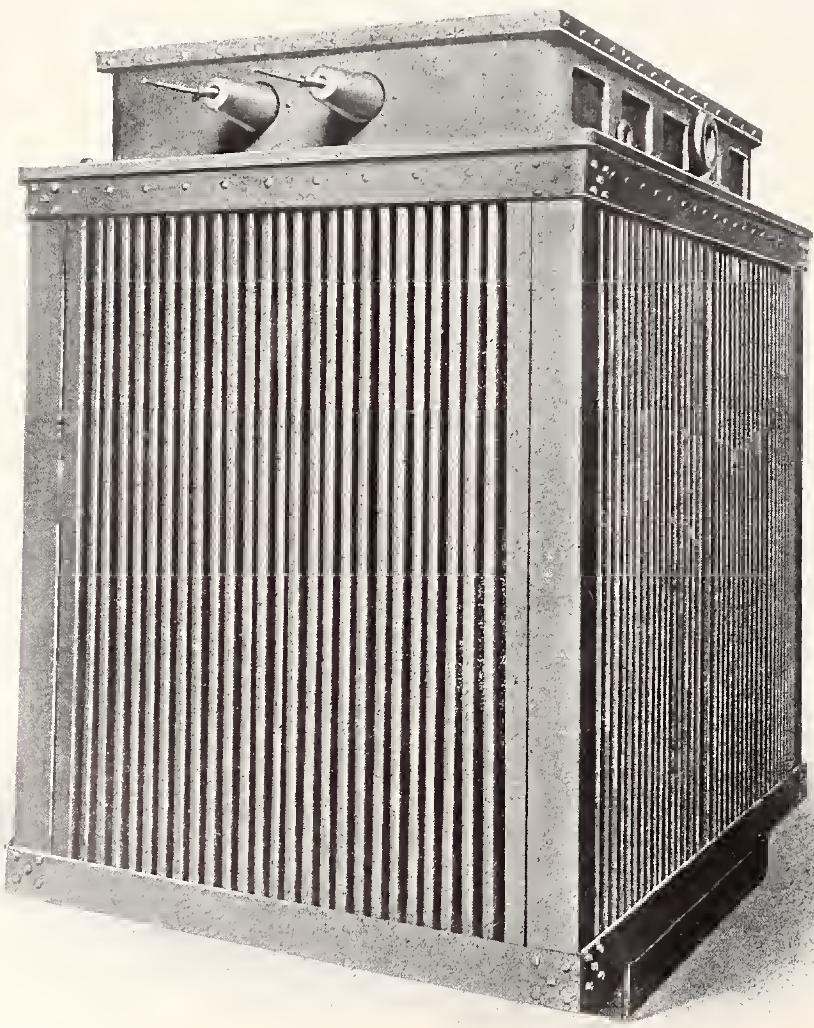
A TYPICAL COIL FOR A LARGE HIGH-VOLTAGE TRANSFORMER

The specific heat of oil per given volume is very great as compared with air, and on account of the great fluidity of oil it will pass through comparatively small ducts, and though traveling at a much slower rate than is required of the air in an air-blast transformer, it produces very effective results, with little chance of local heating.

A mineral oil is used and great care is taken in its manufacture to insure freedom from acid, alkali or water, as it is found that a fraction of 1 per cent. of water added to pure oil will reduce its insulation strength by more than 50 per cent. Fortunately, this rate of reduction is not a constant one. The oil should have a high fire test,

ONE OF THE 1250-K. W. WATER-COOLED TRANSFORMERS SUPPLIED TO THE CANADIAN NIAGARA POWER CO., PETERBORO, ONT., BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

STEP-DOWN, OIL-INSULATED, WATER-COOLED TRANSFORMERS.—1870 K. W.,—11,000 TO 2200 VOLTS, AT THE NEW CARBIDE WORKS AT NIAGARA FALLS, N. Y. MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.



THE CASING OF A 500-K. W. SELF-COOLING TRANSFORMER. NOTE THE LARGE AMOUNT OF COOLING SURFACE OBTAINED BY CORRUGATING THE SIDES OF THE CASE

low viscosity and low rate of evaporation.

In the oil-insulating, self-cooling transformer the cooling is effected by means of the outside case which is designed with a large amount of radiating surface exposed to the outside air. A number of different forms of case have been devised, but the one giving the best satisfaction and now used almost exclusively, except for transformers of very small size, is made of heavy sheet metal, corrugated in such a manner as to greatly increase the area of its sides. This sheet iron case is mounted in a suitable framework, which is ordinarily of angle-iron construction. The top of the case is provided with a cast-iron or sheet-iron cover through which the leads are brought out.

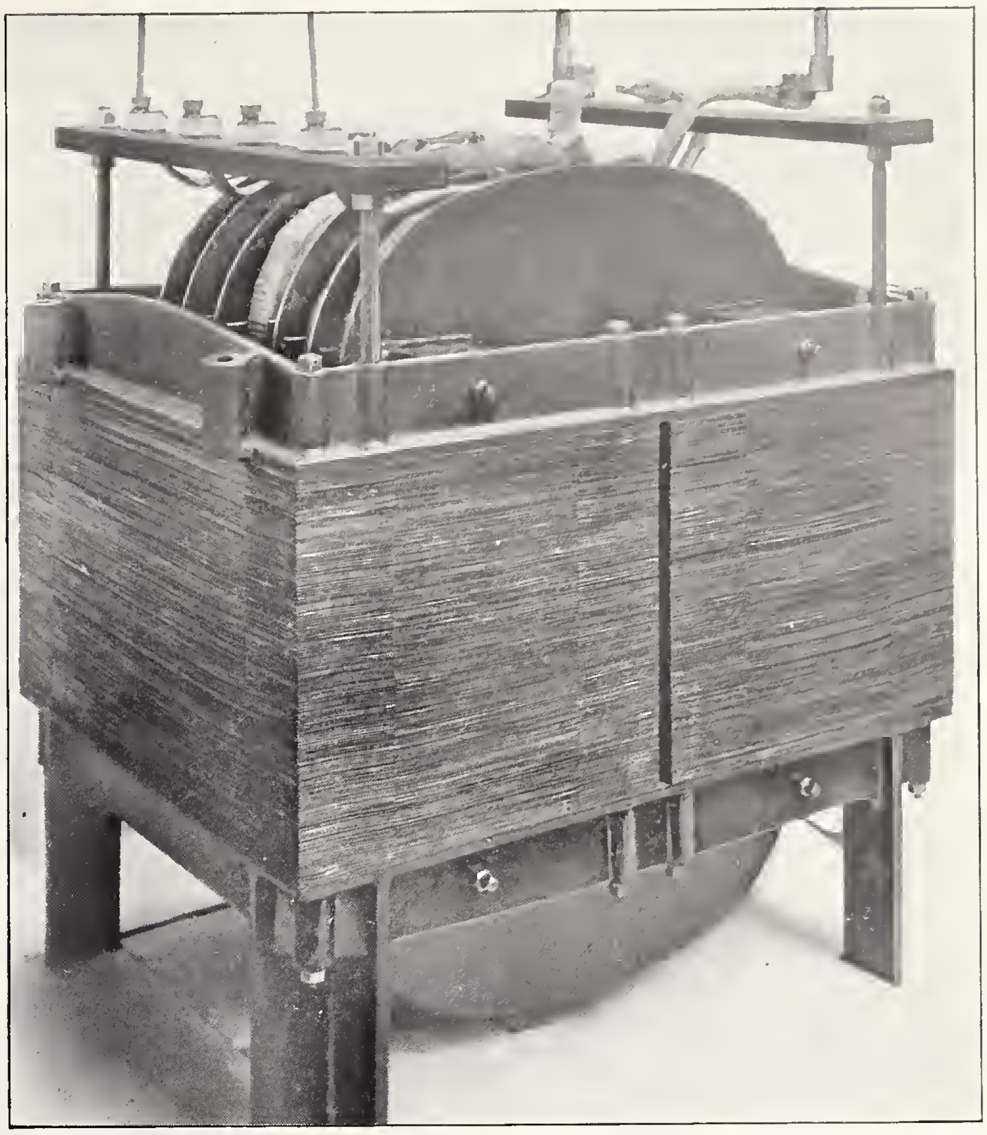
The self-cooling transformer has a distinct advantage over all other types in that no extraneous cooling devices are required, and, after being installed, no attention need be given it. For units not exceeding 500 K. W., particularly when located where they cannot be frequently inspected, the self-cooling transformer is used almost exclusively.

The immense amount of radiating surface required for disposing of the heat generated in a large transformer

limits the capacity for which this type can be built economically to about 500 K. W., so that for larger capacities the oil must be artificially cooled, and for this service water-cooling has been universally adopted.

Several different methods of water-cooling have been tried from time to time, but one system is now used almost exclusively. In this the transformer is placed in a boiler iron case, which rests on a cast-iron bed-plate and is provided with a cast-iron cover through which are carried the terminals from the windings and from the cooling coils. The cooling is effected by circulating water through one or more spirals of brass tubing placed around the inside of the case below the surface of the oil. This gives a simple and direct method of disposing of the heat generated in the transformer, and after the flow of water has been properly adjusted, no attention is required other than an occasional inspection to see that the water rate is properly maintained. A comparatively small amount of water is sufficient for cooling a large transformer; a 2000 K. W. unit, for example, requires approximately five gallons per minute.

It is customary to provide these transformers with thermometers for indicating the temperature of the oil and for sounding a gong as a warning should the temperature of the oil exceed a predetermined value due to a change in the rate of flow of water or from any other cause. The sounding of the gong is accomplished by means of an electrical device. Gauges are also provided for indicating the height of oil in the case, and provision is made so that samples of oil may be drawn off from the bottom of the case for testing the quality of the oil.



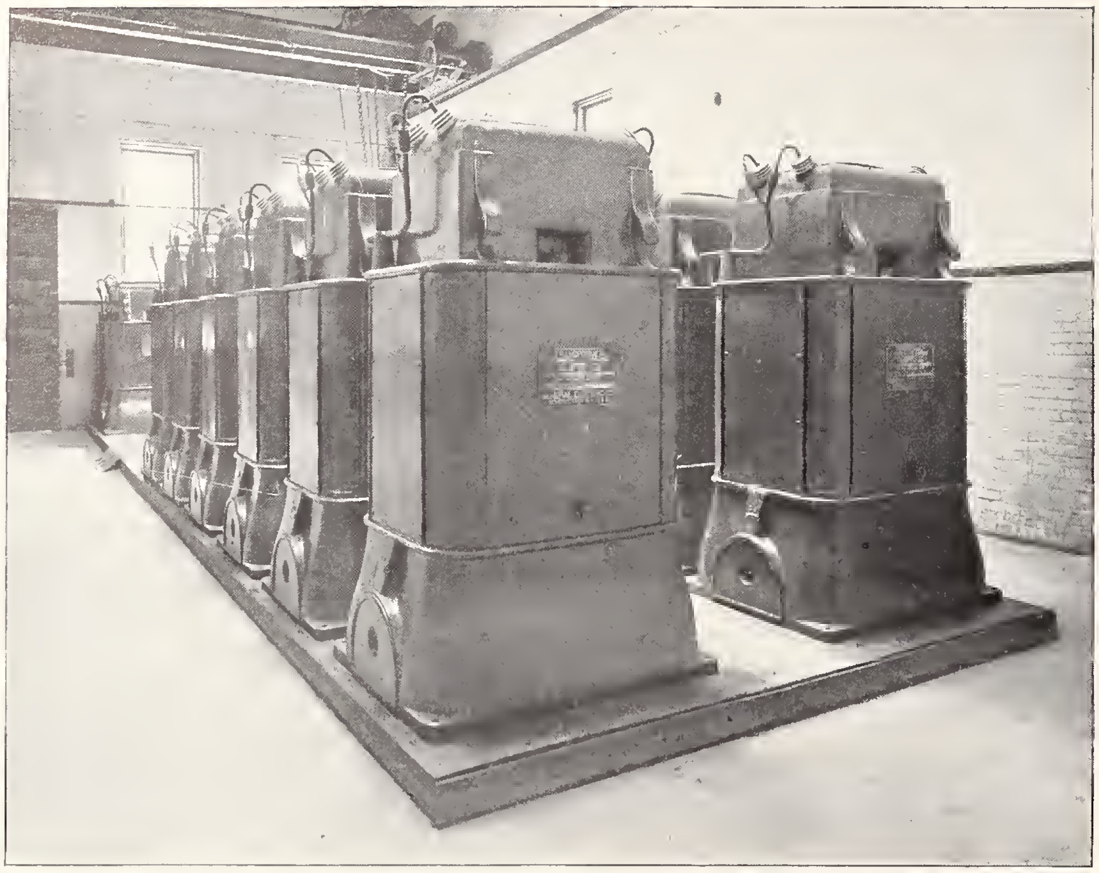
A 2100 TO 60,000 VOLTS TRANSFORMER, MADE BY THE STANLEY ELECTRIC MFG. CO., PITTSFIELD, MASS. THE TRANSFORMER IS SHOWN WITHOUT ITS CASE

While the oil used in transformers is not inflammable, and will not burn unless raised to a high temperature, the presence of a large body of oil constitutes, under certain conditions, a fire risk which cannot be ignored, and suitable precautions should be taken for disposing of the oil in case it becomes necessary. This is usually done by providing a large drain pipe at the bottom of the case, which will rapidly empty the tank and carry the oil into a sewer or into a pit suitably located and arranged for its reception.

SEVEN 1875-K. W. WATER-COOLED STEP-UP TRANSFORMERS,—2200 TO 22,000 VOLTS,—USED BY THE NIAGARA FALLS POWER COMPANY FOR ITS INTERMEDIATE-DISTANCE TRANSMISSION SYSTEM. MADE BY THE WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURG

Another ingenious method lately devised consists in bringing out from the highest point in the cover a large pipe which is connected to a sewer or suitable storage tank, while at the bottom of the case another pipe connects to the water mains. In case of fire the connection to the water main is opened and the oil driven out of the pipe at the top of the case, which is left full of water. When the water is withdrawn and the transformer properly dried out, it will probably be little worse for its wetting. This construction requires an oil-tight cover as well as an oil-tight joint between case and cover.

The air-blast transformer, as its name implies, is one in which the cooling is done by means of a forced draught of air. The usual installation consists of a group of transformers placed over an air chamber in which a pressure slightly above that of the surrounding air is maintained by means of a suitable blower. The air



ONE OF THE SUB-STATIONS AT BUFFALO OF THE CATARACT POWER & CONDUIT COMPANY, 4000 H. P. TWELVE 250-K. W. AIR-BLAST STEP-DOWN TRANSFORMERS, MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

which is admitted to the transformer through an opening in the top of the air chamber passes into the base of the transformer, where it divides into two separate circuits, one through vertical ducts between the coils, the other through the horizontal ducts in the iron core. Suitable dampers are provided in both coil and iron circuits for controlling the amount of air. A fan or blower is used which is designed to give a large volume of air at a low pressure. It is ordinarily direct connected to a motor.

Aside from the outer case or housing, the construction of oil-insulated and air-blast transformers is quite similar, though in the latter type greater insulating distances and larger cooling ducts are required, so that for equal size and voltage the efficiency of the air-blast transformer is usually lower than that of the oil-insulated type.

It has been found that with the insulating materials now available it is difficult to manufacture commercially air-blast transformers for pressures higher than approximately 30,000 volts, so that the air-blast transformer is practically barred from transmissions over very long distances.

A comparison of the three types of high-voltage transformers—self-cooling, water-cooling and air blast—shows that while for certain classes of service any one may be chosen, there is a field for which each is particularly well suited. The self-cooling transformer for moderate sized units of high and low voltage is particularly fitted for use in small sub-stations where no regular attendance can be given; the water-cooled transformer for units of large capacity and for any voltage is especially suited for very large stations where cooling water may be easily obtained; the air-blast transformer, for units of any size and voltages not exceeding approximately 30,000, may be used for large stations where there is constant supervision and where the presence of oil required by oil-insulated transformers might be considered objectionable.

The transformer has long been known as the most efficient of all commercial apparatus. It may be said, in general, that the efficiency increases with the size of the unit, decreases with increase in voltage, and increases as the frequency is increased. Efficiencies of 98 per cent. are quite common on commercial transformers of large size, even though wound for comparatively high voltages and low frequencies, while an efficiency of $98\frac{1}{2}$ per cent. has been exceeded on a number of transformers now in commercial service. Full load efficiencies are,

A 550-K. W. WESTINGHOUSE AIR-BLAST TRANSFORMER. 11,000 TO 390 VOLTS, 3000 ALTERNATIONS

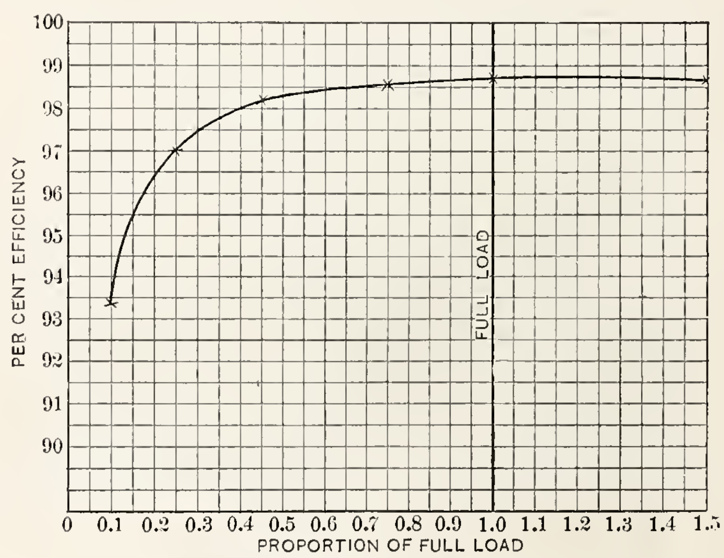


FIG. 1.—EFFICIENCY CURVE FOR A 2500-K. W. OIL-INSULATED WATER-COOLED TRANSFORMER, 45,000 TO 2400 VOLTS, 8000 ALTERNATIONS

of course, referred to; but remarkably high values are also obtained at overloads and at small fractions of full loads.

Not only is the efficiency of transformers remarkably high, but the regulation, which is the drop in voltage from no load to full load, is extremely close, and while it varies somewhat with the character of the load supplied, it is, in general, closer than that of the apparatus in any other part of the system.

For long-distance transmission three-phase currents are used almost exclusively. In the majority of cases the generators are three-phase machines, but there are a number of plants where two-phase current is generated and special step-up transformers are used for changing from two-phase to three-phase.

In America it is customary to group together two or more single-phase transformers for use on polyphase circuits, while in Europe the polyphase transformer is extensively used.

Where the three-phase current is generated and transmitted three transformers are usually employed. They may be connected in delta or in star, or with one winding in delta and the other in star. Methods of connecting transformers are shown in Fig 3, where the generator voltage is assumed to be 1000 and the line voltage 10,000. With the delta connection each transformer is wound for the full voltage of the circuit to which it is connected, while with the star connection each transformer is wound for 58 per cent. of the voltage of the circuit.

In winding transformers for high voltage the star connection has an advantage, for by reducing the voltage on an individual unit it permits a reduction in the number of turns and increases in the size of conductors, giving coils easier to wind and more simple to insulate. The delta connection has, however, a distinct advantage over the star or delta-star arrangement, for in case one transformer of a group of three should become disabled, the two remaining ones will continue to deliver three-phase currents with a capacity equal to approximately two-thirds of the original output of the group.

Quite frequently it is desired to begin the operation of a transmission system at a comparatively low voltage and later to change to a much higher value. In such cases the transformers may be connected at first with both windings in delta, and at a later date the high-tension winding may be changed to star with a resultant increase of 73 per cent in line voltage. For example, transformers wound for 1000 to 19,000 volts, with both wind-

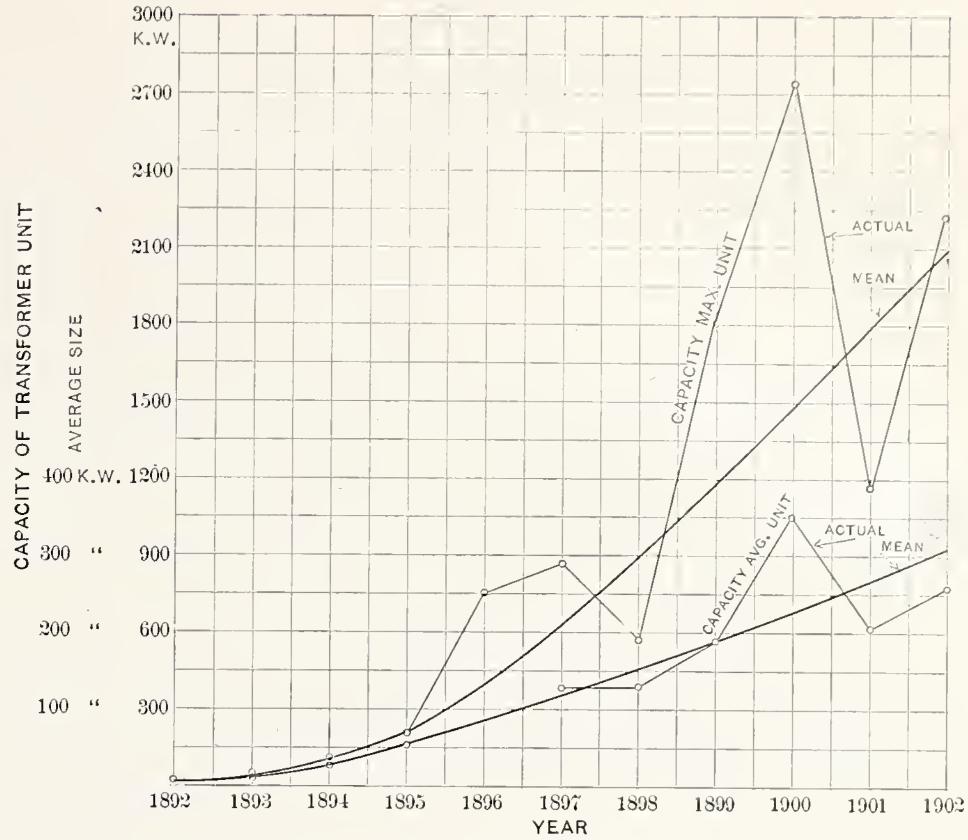
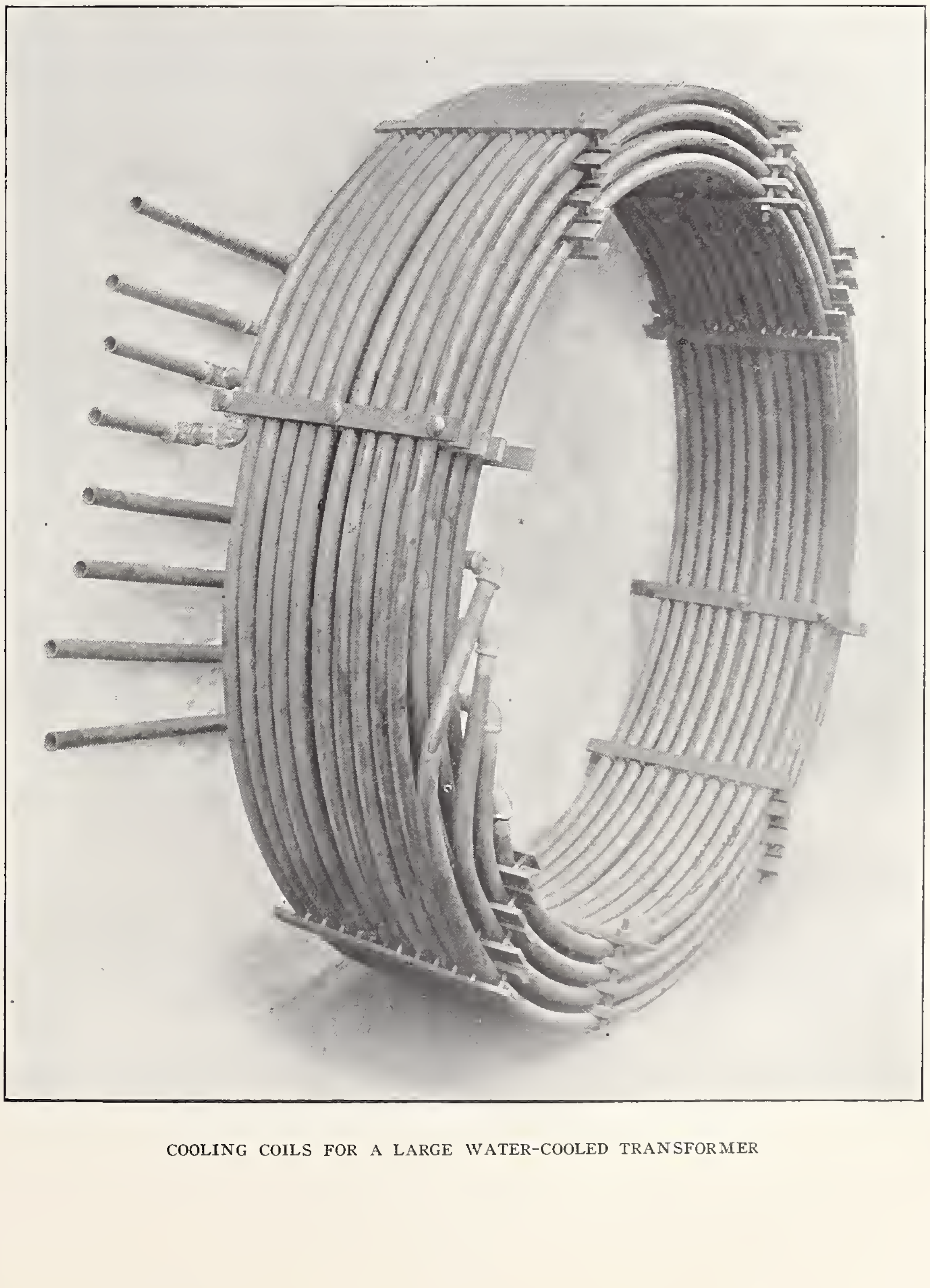


FIG. 2.—CURVES SHOWING MAXIMUM AND AVERAGE CAPACITY OF TRANSFORMER UNITS FOR DIFFERENT YEARS



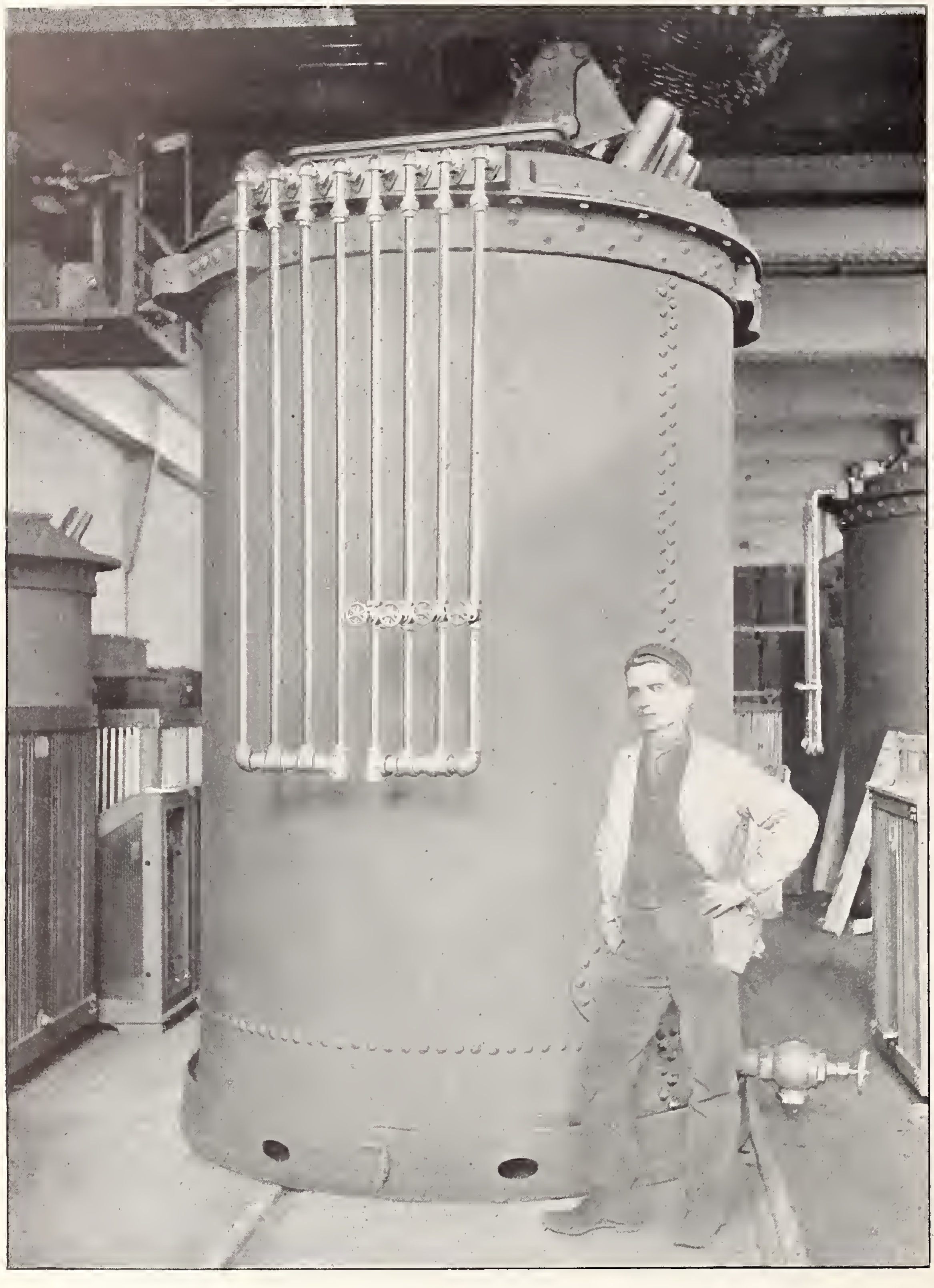
COOLING COILS FOR A LARGE WATER-COOLED TRANSFORMER

ings connected in delta, will give a line voltage of 19,000, but with low-tension windings connected in delta and high-tension windings in star, the line voltage will be increased to 30,000.

Where two-phase current is generated and it is desired to transform it to three-phase current, or when it is desired to change three-phase current to two-phase current, two transformers are used with the well-known connection for this transformation. This method of connecting and the resultant voltages obtained are shown at *c*, in Fig. 3.

Three-phase to three-phase transformations may also be made with two transformers, by connecting in *V* or in *T*. The *V*-connection is simply the delta with one transformer removed. The *T*-connection is shown at *c*, in Fig. 3.

Polyphase transformers may be built for either two-phase or three-phase, but only the three-phase type has been extensively manufactured. This consists essentially of three sets of primary and secondary coils mounted upon a common magnetic circuit. Theoretically, there is considerable economy in this form of construction, both in the amount of material and in the floor space required, but practically the saving is quite small, and on account of reduced flexibility, as well as increased cost of repairs, the three-phase transformer has not been generally adopted in America.



THE CASING OF A 2250-K. W. WATER-COOLED TRANSFORMER. THE COOLING COIL TERMINALS ARE HERE CLEARLY SHOWN

In less than ten years' time the design of the high-voltage transformer has passed through the experimental stage to a firm engineering basis, and while much has yet to be learned, especially regarding extremely high-voltage work, designing methods have so far progressed that results can be predicted with as great, or greater, accuracy than is possible even in the design of steam engines.

The growth in the volume of the transformer business has necessitated greatly increased manufacturing facilities, while the increased size and voltage of individual units have demanded better materials of construction and improved methods of handling apparatus during manufacture. The manufacturer has kept up, however,, with commercial demands, and stands prepared to construct transformers of any size and for any voltage which commercial conditions may require.

In considering the increase in size in voltage and in volume of business, questions which naturally suggest themselves are:

How long will the volume of business continue to increase at its present rate? What will be the maximum size and the highest voltage for which transformers will be wound?

Definite answers to these questions are impossible, but the progress of the past may serve to indicate in a general way what may be expected in the future, and to obtain a record of past progress the curves given in Figs. 1, 4 and 5 have been plotted. These are made up from the data given in the table on page 403, and probably represent quite closely the whole field of high-voltage transformer work.

The curve in Fig. 4, showing the out-put of high-voltage transformesr from 1892 to 1902, inclusive, indicates clearly the effect, upon the transmission business, of the successful outcome of the Pomona and Niagara plants, and of the introduction of the alternating-current motor and rotary converter.

The length of time that this curve will continue at its present angle depends upon the commercial condition of the whole country, and upon developments which may be made in new apparatus or in new applications of old apparatus. At the present time the indications are that for 1903 the rate of increase will be approximately the same as it has been during the last few years.

Fig. 5 shows the rapid increase in maximum voltage of the individual unit, as well as the steady increase in the average voltage of all transformers. As there has been a fairly uniform increase in maximum transformer voltage for ten years past, it seem reasonable to expect that this in-

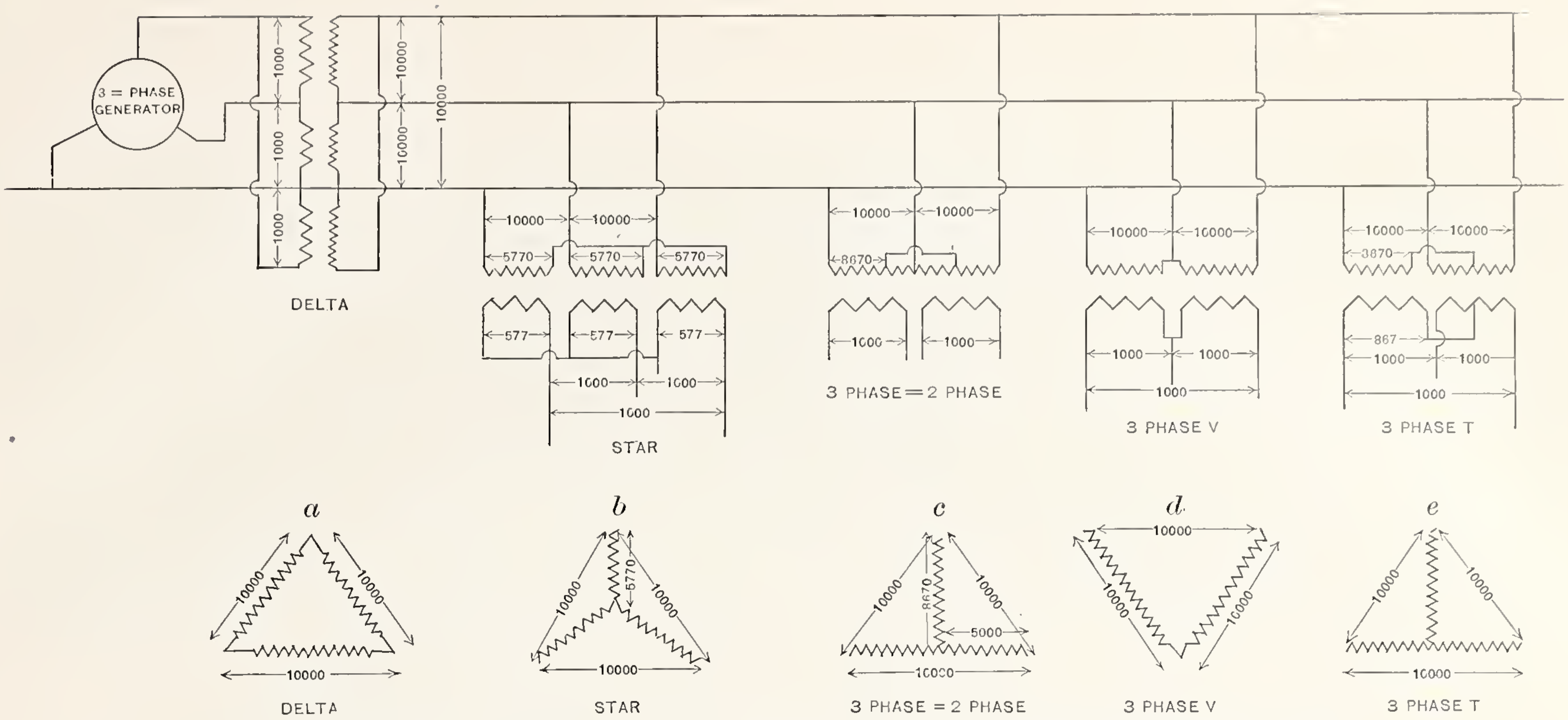


FIG. 3.—METHODS OF GROUPING SINGLE-PHASE TRANSFORMERS FOR POLYPHASE TRANSFORMATIONS

crease will continue for some time to come, and in the course of a few years voltages of 80,000 or even higher may be expected. A knowledge of projected work bears out this inference.

The curve in Fig. 5, showing the average voltage of all transformers manufactured, seems to be growing flat at a little over 15,000 volts. This is due to the great number of transformers used in large cities where power is distributed over wide territories from a central station at voltages ranging from 6000 to 13,000. Unless some new conditions arise, such, for example, as long-distance railway work which will require enormous transformer capacities at very high voltages, it does not seem probable there will be an immediate increase in the average transformer voltage.

The curves in Fig. 2 show the maximum size of transformer for each year, and also the average size of transformer unit.

The upper one of the curves indicating the maximum size shows a wide fluctuation from year to year. The general tendency is, however, upward, and it is expected that with the constantly increasing size of generating units and power plants the demand will be for larger and larger transformer units. The use of transformer units of far larger size than any yet manufactured is even now under consideration, but what the maximum size will be it is impossible even to predict.

The curve showing the average size of unit is a more uniform one than that indicating the maximum size, and is rising gradually. There seems no reason to expect that constant conditions have been reached in this respect, but rather that the increase of the past will continue for some time at approximately its present rate.

In conclusion, it may be stated that while the past ten years have seen wonderful developments in high-voltage transformer construction, with a great increase in the maximum and average size and voltage of the individual unit, limits have nowhere been reached, so that in future improvements in methods of construction as well as units of larger size and higher voltage may be confidently expected.

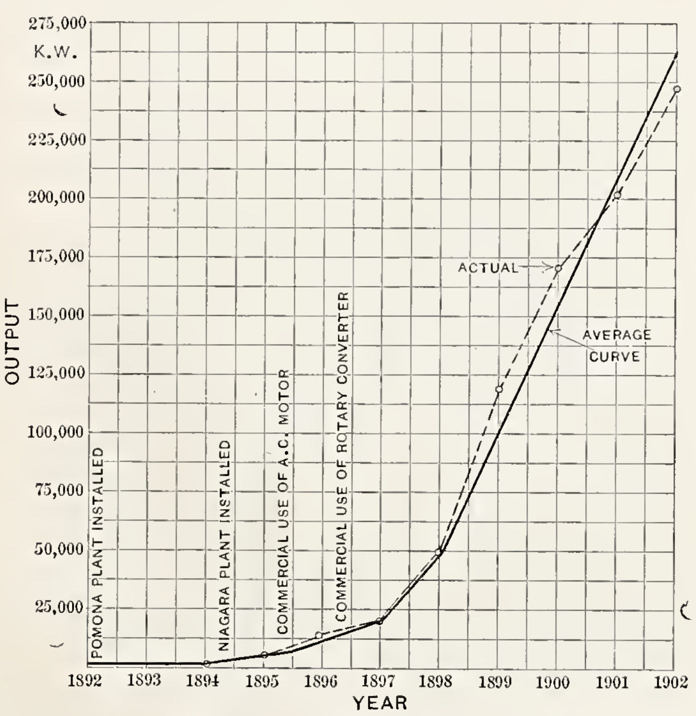


FIG. 4.—CURVE SHOWING OUTPUT OF HIGH-VOLTAGE TRANSFORMERS FROM 1892 TO 1903

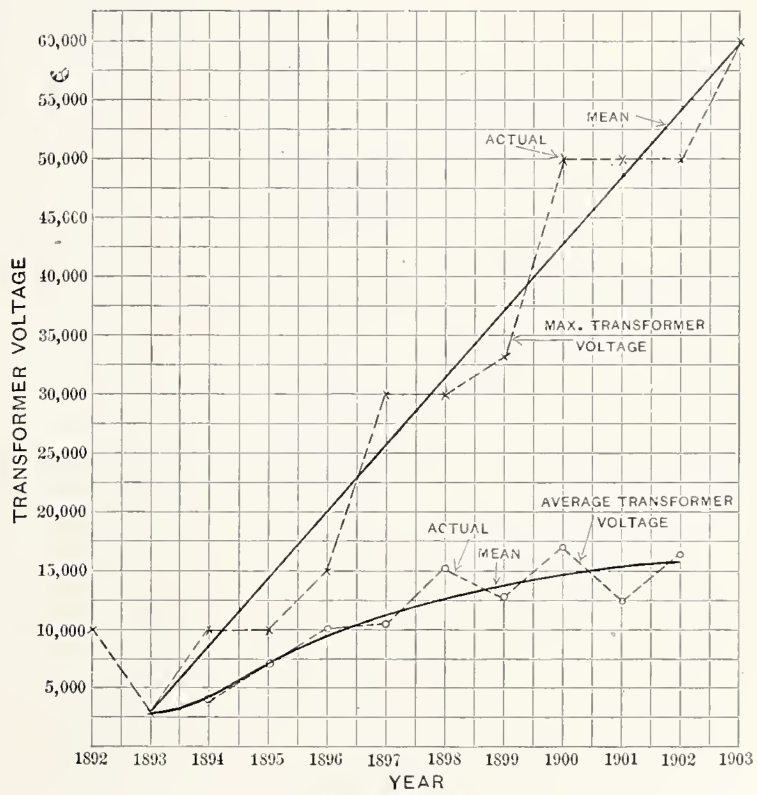
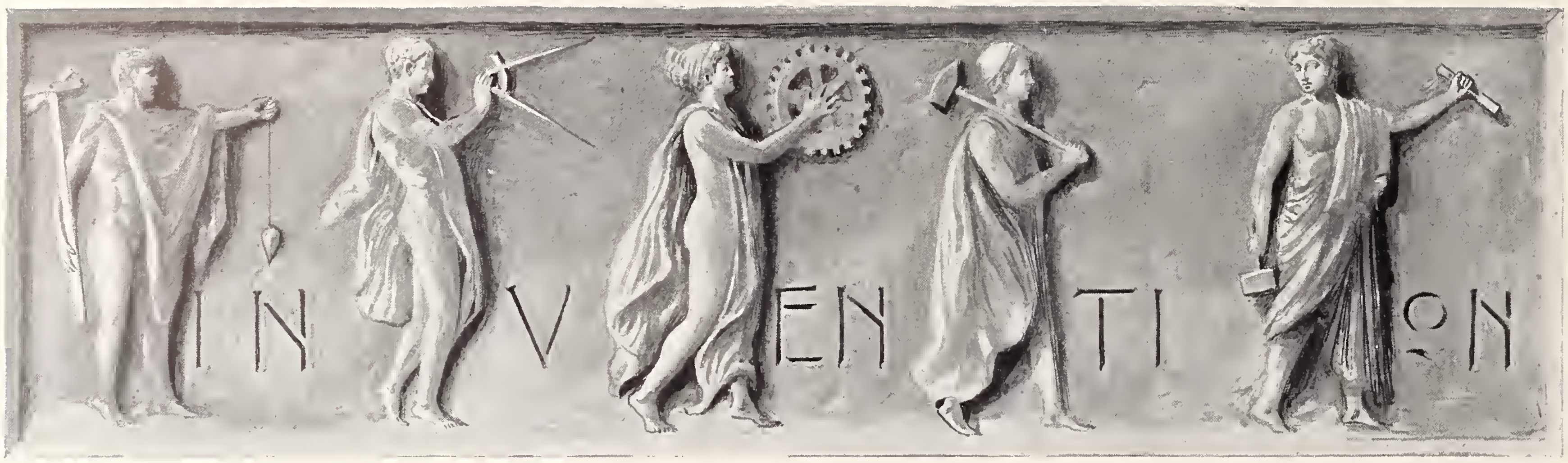


FIG. 5.—CURVES SHOWING MAXIMUM AND AVERAGE TRANSFORMER VOLTAGES FROM 1892 TO 1903



Electrical and Mechanical Progress

Electric Power Looms

THE adaptability of electricity, says the London "Electrical Engineer," is exemplified in some of the French and German manufacturing towns where most of the work is done at home. In Lyons, a silk-weaving center, for instance, an electric distribution scheme was begun in 1895, and some 500 looms are now supplied. For £3 2s. 6d. a loom is provided with power and light about $11\frac{1}{2}$ hours per day all the year. At St. Étienne electric driving has been utilized to a still larger extent for ribbon work. The charge for current is £3 15s. per year, and the rental for the motor 10d. per month. In 1901 some 3100 weavers with a total of 7000 looms were supplied with current. In the parish of Anrath, near Krefeld, Germany, a ribbon-weaving district, an electric supply company for furnishing power and light to weavers was formed three or four years ago, and now supplies about 1000 house workers.

Electrically-Driven Portable Air Compressors

THE use of compressed air has reached such a point of development at the present day that an air compressor may be said to be an almost indispensable adjunct to the equipment of a modern shop. The compressor is sometimes driven by steam engine, either direct-connected or belted, but the electric motor-driven type is the most convenient for most kinds of work, especially in an electric railway shop for blow-torch and sand blast use, and for operating pneumatic tools. The work demanded from such an air compressor outfit seldom lasts for any length of time; hence the compressor may be comparatively small in size, with storage tanks of sufficient capacity to supply all demands.

An outfit of this latter type, put on the market by the National Electric Company, of Milwaukee, Wis., is shown in Fig. 1 of the accompanying illustrations. The compressor is geared to the motor, and an automatic governor is provided to start and stop the compressor between any desired minimum and maximum pressure. Compressor and storage tanks together are mounted on a truck, so that they can be easily moved about.

Compressor outfits of this kind are finding a constantly widening field of usefulness. In connection with automobiles, for example, tires require air inflation to a degree not easily obtained by hand power. Here the advantage of the power compressor is at once apparent. Its special usefulness, perhaps, lies in its ability to provide air in such quantity that it may be stored for use at any time.

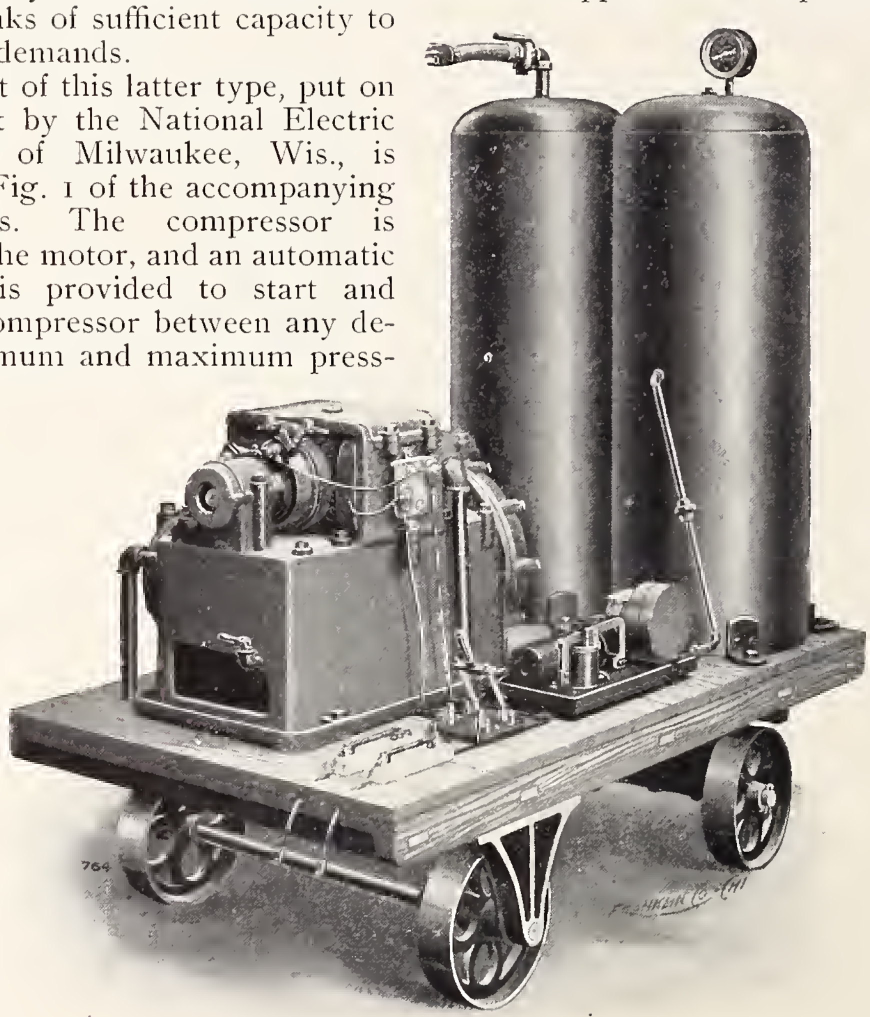


FIG. 1.—AN ELECTRIC PORTABLE AIR COMPRESSOR MADE BY THE NATIONAL ELECTRIC COMPANY, MILWAUKEE, WIS.

The outfit may be kept in garages or other places for storing automobiles where electric connection is

available, and with a practically constant pressure in the air tanks, the air may be used at any time for tire-inflation, for dusting cushions or for storing a supply in a tank carried on the automobile. The latter is generally waukee. Fig. 3 shows how readily an automobile tire can be inflated with it. It is claimed that the work can be done in less than a minute and a half, the ordinary air pressure in the tire being 90 pounds per square inch.

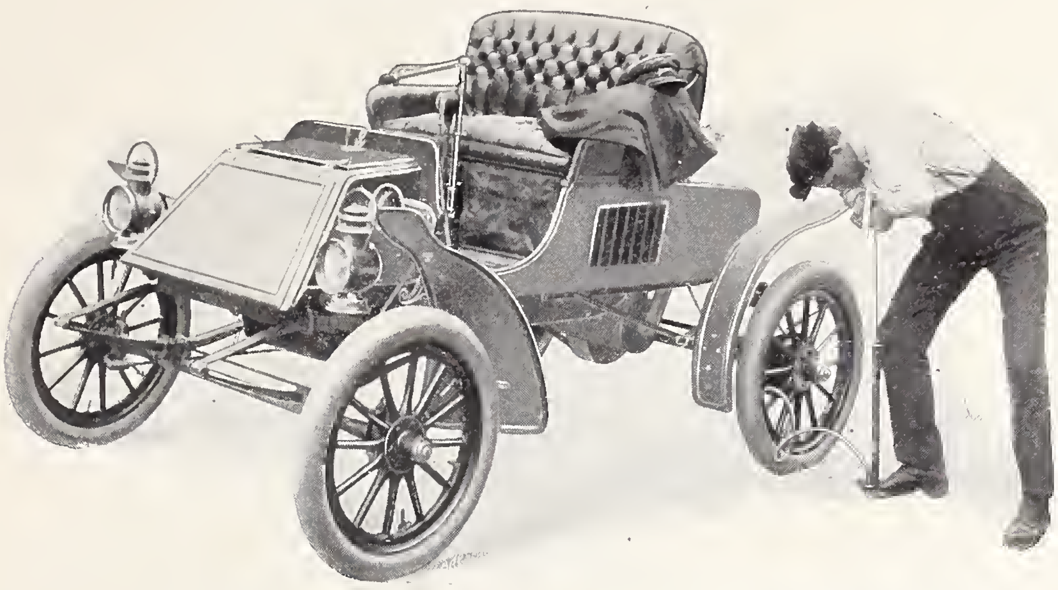


FIG. 2.—THE OLD WAY OF INFLATING AUTOMOBILE TIRES

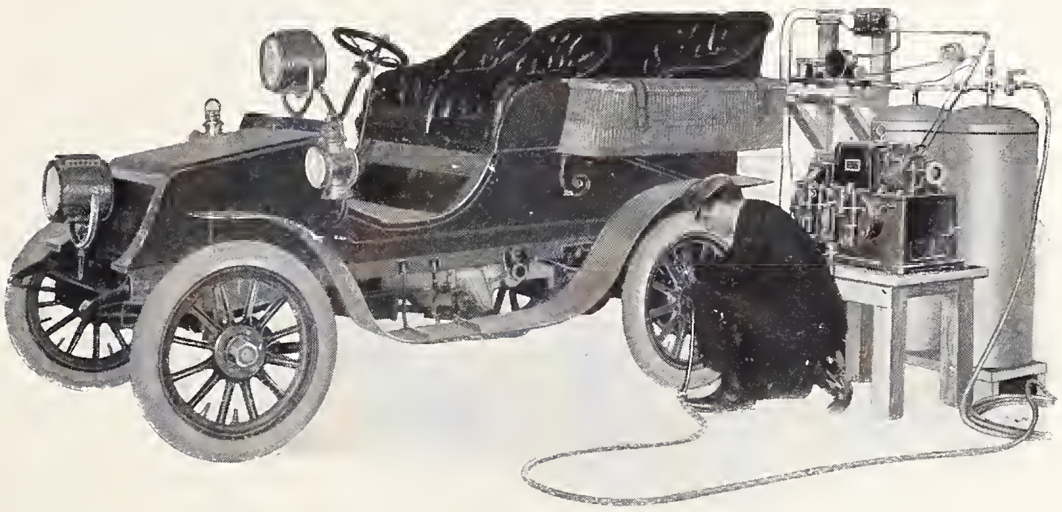


FIG. 3.—INFLATING TIRES WITH AN AIR COMPRESSOR OUTFIT MADE BY N. A. CHRISTENSEN, MILWAUKEE, WIS.

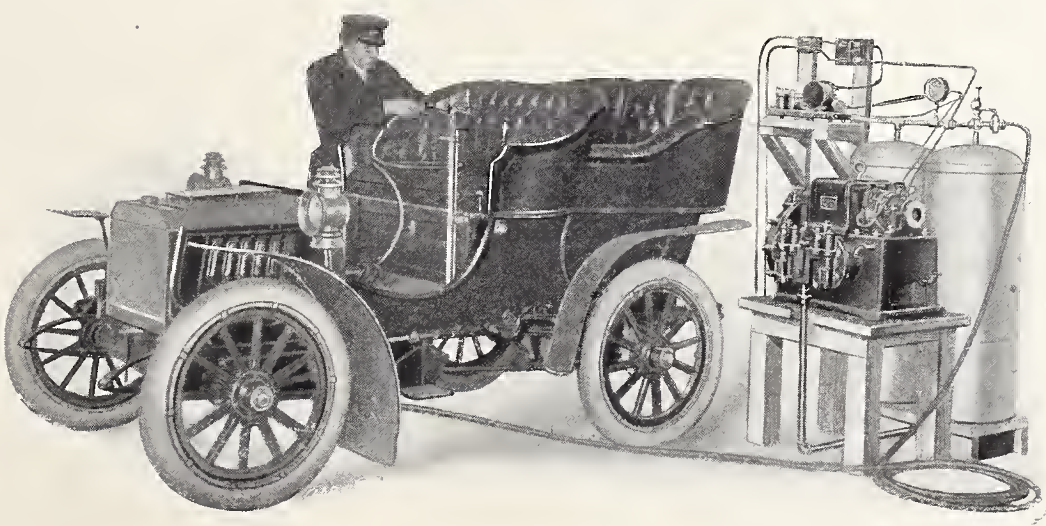


FIG. 4.—CHRISTENSEN'S COMPRESSOR FOR AUTOMOBILE CLEANING

provided of sufficient size to furnish air for three or four complete 90-pound tire inflations before recharging is needed.

The outfit shown in Figs. 3 and 4 is made by N. A. Christensen, of Mil-

Another advantage of the apparatus is that with it a tire can be inflated at uniform pressure by the gage, which is a very important point; overcharging of the hand-pump method ruins many tires.

As an effective cleaning agent, compressed air has quickly worked its way into favor. Everyone initiated in automobiling knows how dust-laden everything in and about the machine becomes after even a short run. Fig. 4 shows how readily this dust can be removed from all crevices and inaccessible places by a jet of compressed air. From the engine and running gear the dust is readily removed in the same manner.

The feature of keeping the working parts clean without continually wiping with waste or rags is a very important one, and tends to save time as well as wear and tear. As to the convenience of the method, the illustration tells its own story.

A New Vertical Corliss Engine

AMONG the many of that most conspicuous type of engine, the vertical Corliss, exhibited at the St. Louis Exposition, is one built by the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, and shown in the accompanying ilustrations. This Hamilton-Corliss cross-compound design, of cylinder dimensions 34 x 68 x 54 inches, is direct-connected to a 1500-K. W. alternating generator.

It runs at a speed of eighty-three revolutions per minute; the main bearings are 25 inches in diameter and 42 inches long; the shaft in the wheel and the generator is 30 inches in diameter; the crank is 11 inches in diameter and of the same length, and the wheel is 22 feet in diameter, weighing 120,000 pounds. This last is made in eight segments, there being a section of the rim and one arm to each segment. These segments are bolted to the hub, which is made of two separate discs forced on the shaft, and the rim is clamped together with steel arrow-head links shrunk into place.

The bed-plate is of the box-section type and forms a deep crank pit to retain oil. The main bearing portion is bored and faced to receive the bottom box, which is of the shell type arranged for water circulation. The "A" frame is cast in two pieces strongly webbed. The lower portion is of box section, and gradually changes to circular section as it reaches the top. The guide barrel is circular in form, slightly flattened on the sides at the openings provided for fitting oil shields and doors.

The exhaust chambers in the cylinders are separated from the cylinder walls by an air space. The valves are located in the barrels to avoid the inconvenience of having to disconnect

the valve gear when the heads are removed. The valves are, however, placed in such a manner as to reduce the clearance to about that obtained when they are placed in the heads, by bringing the exhaust valves partly within the cylinder walls, although at no time do the valves enter the space swept by the piston, and the piston is allowed to sweep past the ports. The arrangement is different on the steam-valve side. The ports on this side are so arranged that the in-coming steam strikes the piston squarely on the end, thus preventing any side shock or pound common to the vertical type of engine. Both steam and exhaust valves are double-ported, and have a very short travel. The valves are cored and made as light as possible.

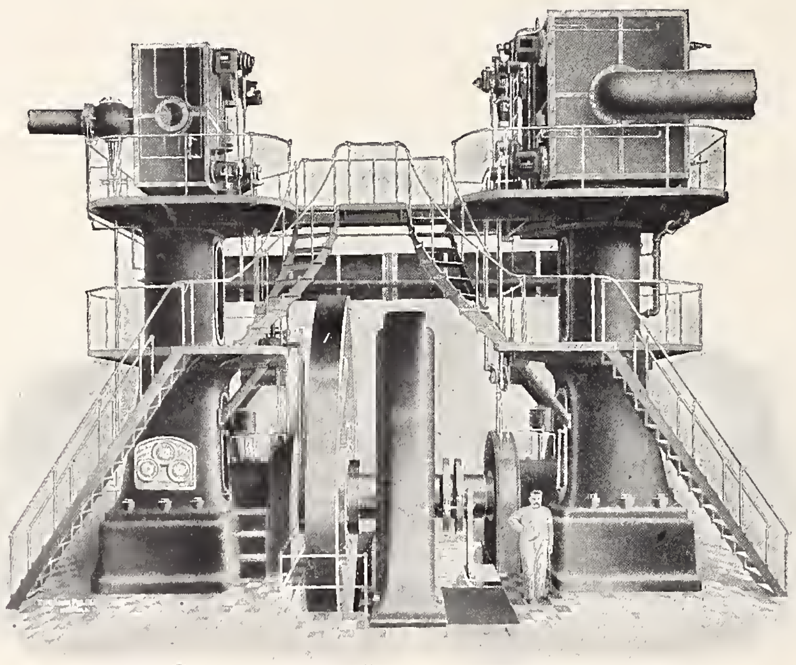
The pistons are cored; they have a follower ring and one sectional ring pressed out by spiral springs, which are held in place by tee-headed brass bolts. They are made a taper fit on the rods and locked with a jamb-nut and keeper. The cross-head is of steel, with cast-iron slippers lined with babbitt, each slipper having a wedge adjustment. The piston rods are threaded in the cross-head and locked with jamb-nuts and keepers. The connecting rod is of the solid-rod pattern, $5\frac{1}{2}$ cranks long, with a wedge adjustment at either end, so arranged as to keep the length of rod and the clearance spaces constant. The boxes are of bronze, babbitted.

The valve gear is shown in some detail in the views of the high and the low-pressure cylinders. It differs somewhat from the regular Hamilton-Corliss type. The steam and exhaust valves are actuated by separate eccentrics, direct, without wrist plates, the necessary motion being obtained by the use of levers and links on each bonnet separately.

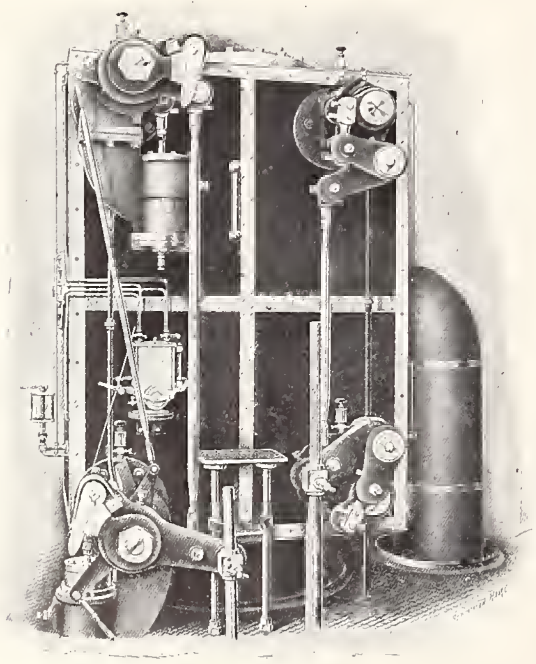
The dash pots are hung from the bonnets and are close to the cylinder, making a very compact and self-contained arrangement. They are of a new noiseless pattern, with the weight of the moving parts greatly decreased, and are adapted for much higher speeds than usual. The dash-pot levers are placed on the valve stems within the opening of the bonnet.

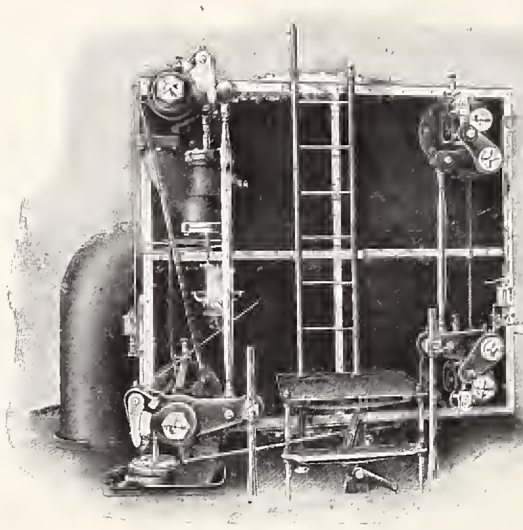
Both steam and exhaust cam rods have efficient unhooking devices, so that the valve gear can be worked by hand to facilitate starting and warming up. The releasing gear hooks and latch-block trip-plates have eight reversible wearing edges, and the links have bronze connections, with key adjustments. The valves are double-ported, and, hence, have but a short travel.

The governor is placed upon the first gallery platform on the high-pressure side. It is of the high-speed, center-weighted, flyball type, with motor and micrometer attachment for regulating the speed from the switchboard for throwing two units in parallel. Both cylinders are under control of the governor, the range of cut-off being from zero to three-quarter stroke.



A NEW VERTICAL CORLISS ENGINE, MADE BY THE HOOVEN, OWENS, RENTSCHLER CO., HAMILTON, OHIO





VALVE-GEAR DETAILS OF THE HAMILTON-CORLISS ENGINE MADE BY THE HOOVEN, OWENS, RENTSCHLER COMPANY

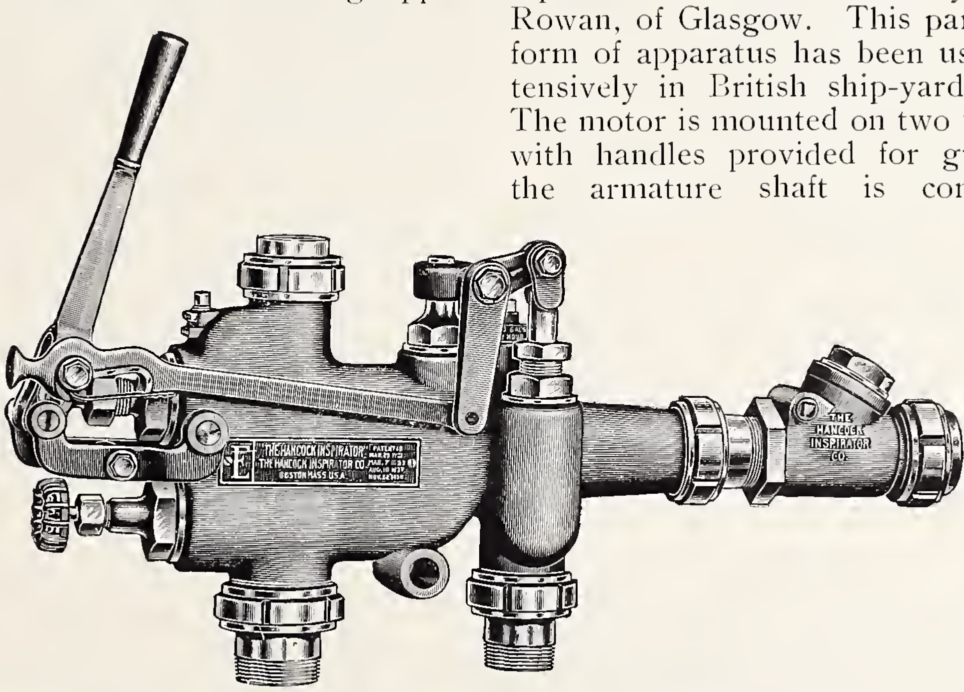
The main bearings are lubricated by a continuous stream of oil, pumped from a tank beneath the floor by an eccentric-driven oil pump to receivers over each bearing cup. The eccentrics, cross-head slippers, cross-head and crank pins are oiled by gravity from multiple sight-feed tanks placed on the upper part of the engine. The cross-head slippers have wipers at the bottom end dripping into reservoirs at each stroke. All the valve gear, rocker arms, etc., are lubricated with grease cups. The engine is thoroughly provided with oil guards and shields, and the arrangement of stairways, galleries and platforms is such as to make all parts accessible.

The Hancock Locomotive Inspirator

A LOCOMOTIVE inspirator, designed to meet the present demand of railroads in standardizing their equipment, is the latest production of the Hancock Inspirator Company, Boston, Mass. It is of the lifting type, and is so made that by merely changing the nozzles and tubes it will be capable of delivering maximum capacities ranging from 2500 to 5000 gallons per hour at a steam pressure of 200 lbs. per square inch, lifting water 4 feet vertically with the feed-water at 75 degrees F. By its use rail-

roads are able to have one standard size inspirator for all sizes of locomotives, it being only necessary to insert in the inspirator the nozzles and tubes for the proper capacity to supply the locomotive. Thus only one size of spare inspirators and but one size of repair parts are required.

In principle, this inspirator is similar to the other Hancock inspirators. It comprises a lifting apparatus, which lifts the water, and a forcing apparatus, which forces the water into the boiler, the lifting apparatus acting as a governor, delivering the proper amount of water to the forcing apparatus for the proper condensation of the steam.



A NEW LOCOMOTIVE INSPIRATOR MADE BY THE HANCOCK INSPIRATOR CO., BOSTON, MASS.

The inspirator is capable of feeding the boiler at any steam pressure between 35 pounds and 350 pounds per square inch without any adjustment of either the steam or water supply, and when the inspirator is in full working position at any steam pressure between these limits it cannot discharge the water except through the delivery pipe leading into the boiler. It will handle hot feed-water, and, from tests, it has been found that it will start and feed the boiler reliably with the supply water at 135 degrees F. with 110 pounds steam pressure, at 137 degrees with 140 pounds pressure, at 135 degrees with 160 pounds pressure, at 130 degrees with 200 lbs. pressure, and at 123 degrees with 225 pounds pressure.

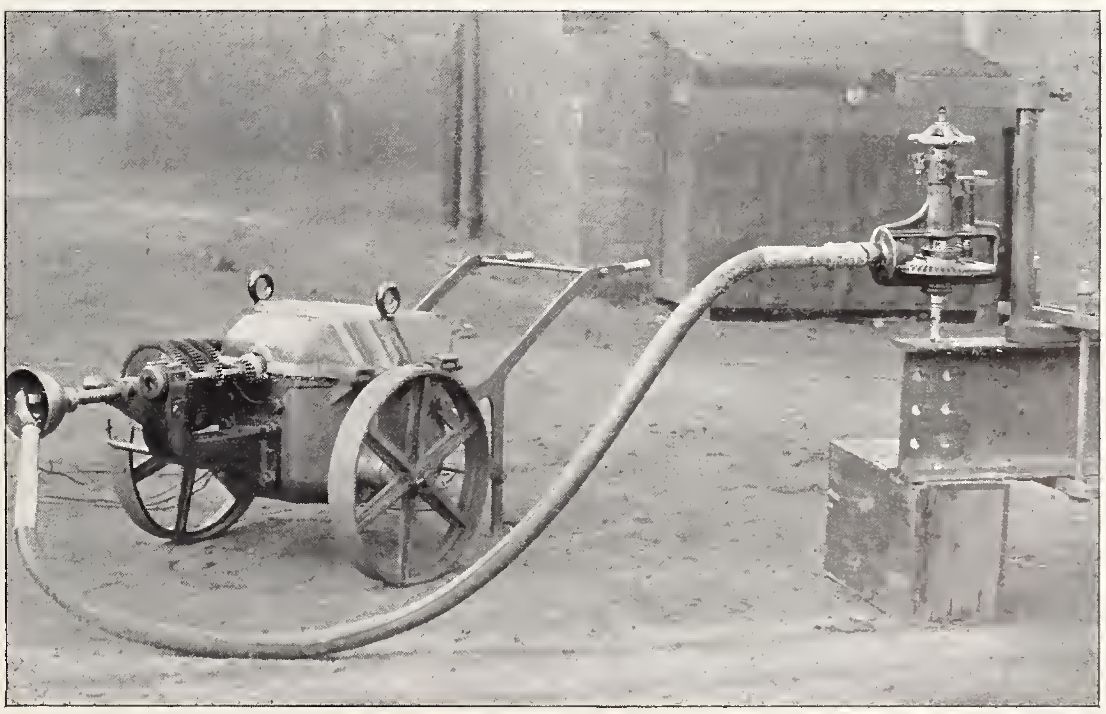
The capacity of each set of nozzles and tubes can be regulated for light or heavy service of the locomotive. It has been found that with cold feed-water the minimum capacities will not be more than 45 per cent. of the maximum capacity with 160 pounds steam pressure, 48 per cent. with 200 pounds pressure, and 54 per cent. with 225 pounds pressure. A minimum capacity as low as 1100 gallons per hour may be obtained when the 2500-gallon nozzles and tubes are used.

A Portable Electric Drilling Outfit

A GOOD example of British practice in the use of portable electric drilling machinery is shown in the annexed cut, which represents an outfit made by F. J. Rowan, of Glasgow. This particular form of apparatus has been used extensively in British ship-yard work. The motor is mounted on two wheels, with handles provided for guiding; the armature shaft is connected through gearing to a flexible shaft which operates the drill. The carrying wheels are mounted on trunnions cast on the case, and two legs are provided on the handle frame for keeping the motor upright. The armature shaft extends outside of the case, the outer end running in an outboard bearing-frame bolted to the motor case.

The outboard frame also provides bearings for the transmission-gear shaft, on the end of which is placed the universal coupling to the flexible shaft. The outer end of the flexible shaft gears with the drill body, the latter being provided with a power feed.

The arrangement is obviously one that will prove convenient for a variety of work, and the ease of power supply by a mere extension of wires makes the field of operation in a ship-yard practically unlimited.



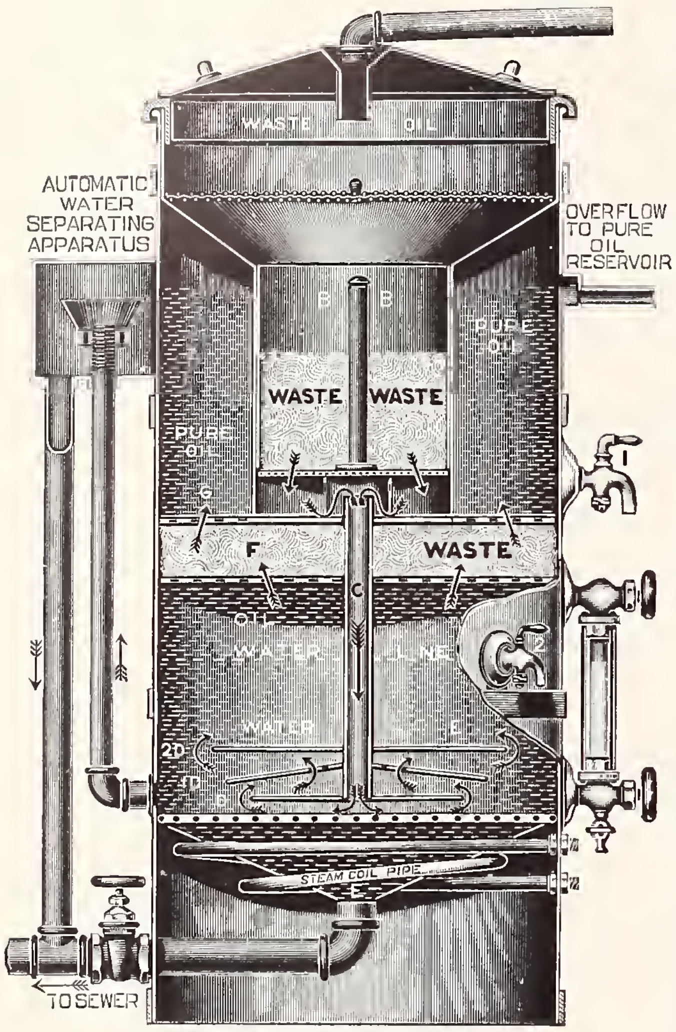
A PORTABLE ELECTRIC DRILLING OUTFIT MADE BY F. J. ROWAN, GLASGOW

A Filter for Saving Oil

A FILTER, made by the Burt Manufacturing Company, Akron, Ohio, for separating oil in the condensation from oil separators and exhaust heads, is shown in the accompanying illustration. In this filter the oil and water are automatically separated, the oil, after being purified, is stored in a reservoir, and the water is discharged from a drip into the sewer. The filter is made in several sizes, from 3 to 500 gallons per day capacity.

As shown in the illustration, the oil and water are poured into the top of the filter and then pass into the chamber *B* through a layer of waste, which collects all the heavier impurities of the oil. Thence it passes through the perforated bottom of the chamber *B*, in the direction shown by the arrows, into the tube *C*, and from there on to the filter plate *D*, where the increased weight of the water has a tendency to keep the oil back in the tube *C*. However, the pressure of oil in the chamber *B* forces the oil down and spreads it out over the plate *D* in a very thin film, which constantly changes surface and grows thinner as it travels from the center to the circumference of the

plate D, thus exposing every particle of waste oil to the action of the water. The oil then flows upward on the plates $1D$ and $2D$, going through the same process in each case. When the oil leaves the filter plate $2D$ it is in a finely divided state, and is thoroughly washed out by being mixed with



AN OIL FILTER, MADE BY THE BURT MANUFACTURING CO., AKRON, OHIO

water. All the remaining impurities separate from it by gravity and settle in the chamber E, from which they can be removed by opening the gate valve at the bottom of the filter, which drains off all the water and dirt.

From the plate $2D$ the oil again filters through the stratum of material F, and from there it rises to the pure oil chamber and then flows to the oil reservoir. The water is automatically separated after it passes down the tube C and reaches the bottom plate; as the oil is lighter than water, as soon as it reaches the bottom of the filter it immediately rises, and the surplus water passes into the tube leading to the automatic water-separating device.

St. Petersburg, Russia, is soon to have a new and thoroughly up-to-date telephone exchange, the ultimate capacity of which is to be 40,000 subscribers. The exchange will be installed by the Western Electric Company, of Chicago.

New England Water Powers

According to "The Iron Age," New England water powers are being prospected with a good deal of system with the purpose of developing them for electric purposes. The possibilities contained in the rivers of these States are considered to be tremendous, in view of the rapid progress which long-distance transmission of electric power is making. Not a few New England manufacturers look to see the undeveloped and neglected water power of the section make up, to a considerable extent, for the distance from the coal mines, which is the chief disadvantage of manufacturing in the Northeastern States of the Union. In a country that is either mountainous, or at least hilly in practically every section, reservoir sites may be found in plenty to provide against the times of low water, which is the chief drawback of the water power of New England as already developed.

Personal

Wallace C. Johnson, consulting engineer of the Niagara Falls Hydraulic Power & Manufacturing Company, is reported to have been engaged by the Sientere Viva Mining Company, Bluefields, Nicaragua, to prepare plans and specifications and to construct and equip an extensive electric power plant and transmission system in that locality.

Walter H. Whiteside, formerly with the Westinghouse Companies, has joined the staff of the Allis-Chalmers Company, of Chicago, as general manager of sales for all departments, including the Bullock Electric Manufacturing Company, which has become the electrical department of the Allis-Chalmers Company. His experience thoroughly qualifies him for this important duty, which he takes up with the good wishes of his very wide circle of business acquaintance. Mr. Whiteside will enter upon his new duties about the middle of July.

H. F. Fervert, who for the past several years has been manager of the New York stores of the Niles-Bement-Pond Co., and the Pratt & Whitney Co., has severed his connection with these firms and opened an office at 114-118 Liberty street, New York, for the sale of machinery. Mr. Frevert also is manager of the New York office of the Norton Grinding Co., of Worcester, Mass., manufacturers of emery grinding machinery, and of the Brightman Mfg. Co., of Shelby, Ohio, manufacturers of turned shafting and machines for turning, rolling, straightening and polishing shafting.

Max Loewenthal, secretary and electrical engineer of The Prometheus Electric Company, of New York, has returned East from a four months' trip in the interests of this company, having during that time visited almost every large city in the United States as far West as Denver, Col., establishing agencies for the sale of Prometheus electric heating and cooking apparatus. The goods were well received everywhere, and in the opinion of Mr. Loewenthal, after having thoroughly canvassed the situation, the immediate prospects of the electric heating business are very encouraging. In addition to the business features of the trip, Mr. Loewenthal enjoyed an excursion through the mining camps of Colorado and a trip to the St. Louis Exposition.

The following story of Charles P. Steinmetz, chief engineer of the General Electric Company, is told by Arthur Goodrich in "The World's Work":—"Some years ago Steinmetz went into the Adirondacks with a hunting party of friends. Not caring to hunt, he was often left alone at a little lodge that was made the

C. P. STEINMETZ

party's headquarters. One night before the camp fire a mathematical question came into his head. To settle it he needed a table of logarithms which could not have been found within miles of the camp. He remembered a few figures, and in a short time had worked out an entire

EDWARD WESTON

table of logarithms for himself, and from it solved the problem. This mathematical sense, which was originally trained by hard study at Breslau, makes it possible for him to answer quickly the rapid fire of questions his aids hurl at him daily."

In addition to the degree of L.L.D. recently conferred upon Dr. Edward Weston, president of the Weston Electrical Instrument Company, of Waverly Park, N. J., by McGill University, the further honor of the degree of D.Sc., has just been accorded to him by Stevens Institute.

Robert McF. Doble, of San Francisco, consulting and supervising engineer, who has made a specialty of hydro-electric power development and long-distance power transmission, is now associated with the Abner Doble Company, also of San Francisco, engineers, and manufacturers of tangential water-wheels. Mr. Doble will have charge of the consulting engineering department of the company in the design and construction of power plants, pumping plants and other engineering work.

A. M. Mattice, chief engineer of the Allis-Chalmers Company, of Chicago, has returned from his European tour of inspection, and has now settled down to the duties of his position in Milwaukee. While in Europe Mr. Mattice visited the hydraulic machinery works of Messrs. Escher, Wyss & Co., of Zürich, Switzerland, and arranged important details concerning the manufacture in the United States of their lines of product. He also inspected the Nürnberg Gas Engine Works, at Nürnberg, and, at the well-known engineering establishment of Willans & Robinson, at Rugby, England, he paid particular attention to the products and methods of manufacture of the Steam Turbine Advisory Syndicate, of which important organization the Allis-Chalmers Company is the American member. Mr. Mattice had several important consultations in London with Mr. Yarrow, the well-known torpedo boat builder, on the subject of turbines for marine purposes, and while on the Continent he made, in the Allis-Chalmers interests, a series of exhaustive tests of the Zoelly steam turbine, of which so much has recently been heard.

Prof. Wm. F. Durand, of Sibley College, Cornell University, has accepted the directorship of the college of mechanical engineering at Leland Stanford, Jr., University.

Obituary

James A. Myers, president and treasurer of the Robbins & Myers

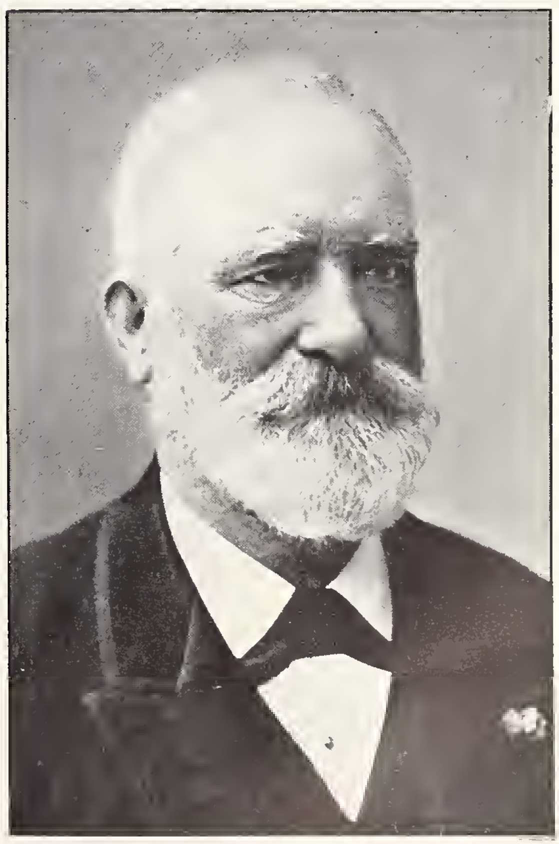
JAMES A. MYERS

Company, of Springfield, Ohio, died at his home in that city on May 27. Mr. Myers had returned on April 22 from an extended business trip, and seemed at that time in the best of health. He became ill shortly after, however, and soon developed symptoms of typhoid fever.

He was born in Jamestown, Ohio, in 1851, and was educated at Bowersville Academy, going to Springfield in 1876, where he engaged in business. In 1878 he became interested with Mr. Robbins in the iron foundry business, in 1889 forming the present Robbins & Myers Company, and becoming its president on the retirement of Mr. Robbins in 1900, and that office he occupied at the time of his death. He became actively interested in electrical affairs in 1896, about which time his company entered the electrical manufacturing field. From that time his acquaintance among members of the electrical fraternity increased rapidly, until at the time of his death he numbered among them many friends in all sections of the country. Mr. Myers was successful in affairs, and to his energetic and careful management the prominent position of his company is largely due. He leaves a wife and two sons.

The recent death at Washington, D. C., of William Wallace, has removed a figure of interest and prominence from the electrical field, even though the name may have an unfamiliar sound to the younger members of the profession.

According to a series of articles dealing with his achievements, and prepared by Mr. William J. Hammer for "The Electrical Engineer" in 1893, Wallace was the first builder of dynamos in this country and the first manufacturer in America to apply the dynamo to the industrial art of electro-plating. Prof. Moses G. Farmer was associated with him in the manufacture of the Wallace-Farmer dynamo, one of which was used at the Centennial Exposition of 1876 to supply the first electric lights in service. He also established, with his brother, a large electro-deposition plant at Ansonia, Conn., for the purpose of



WILLIAM WALLACE

plating with copper the steel wire used in 1883 by the Postal Telegraph Company, in conjunction with Prof. Elisha Gray's harmonic telegraph between New York and Washington, Chicago and St. Louis.

In 1875 Mr. Wallace invented and constructed the first arc lamp made in the United States, consisting of two battery carbon plates fastened in a wooden frame. He afterward improved the lamp to make it regulate automatically, and was the first to operate arc lamps in series. He claimed the invention of the round, pencil carbons, and erected a plant to make them, designing tools after which those of the present day are modeled. Another product of Mr. Wallace's skill was an induction coil 5 feet long and $12\frac{1}{2}$ inches in diameter, the largest coil in the United States and the second largest in the world. This coil gave a 27-inch spark with six Grove cells.

Many prominent men identified with the electric lighting industry, including Edison, Dr. Henry Draper and Prof. C. F. Chandler, were guests at Mr. Wallace's home at Ansonia. Edison has said of him:—"He is one of the earliest pioneers in electrical matters in this country. He has done a great deal of good work for which others have received the credit; and the work which he did in the early days of electric lighting others have benefited largely by, and he has been crowded to one side and forgotten."

The New York Electrical Society

ANNUAL MEETING.

THE annual meeting of the New York Electrical Society and election of officers was held at the Electrical Testing Laboratories, New York, on June 15. The report of the secretary showed that 101 members had been elected during the year; 54 had been dropped for non-payment of dues; 32 had resigned, and 3 had died, and that the total membership is now 631. The report of the treasurer showed that the income of the society for the year ending January 31, 1904, was $1,502.62, and the balance on hand, $34.37. The revised constitution and by-laws were read for the second time before the Society, and after being submitted to the meeting, were unanimously adopted.

The executive committee of the society deserves the greatest credit for its earnest efforts to strengthen the weak points which heretofore existed in the constitution and by-laws. In order to enlist the best services which the society was capable of affording to this end, the president appointed as a revising committee the three past-presidents of the society, Messrs. Francis W. Jones, the first president of the society; Gano S. Dunn and Arthur Williams. Their revision, which was approved by the executive committee, was that now adopted by the society.

One essential point in the new constitution is that no officer except the secretary and treasurer shall be eligible for immediate re-election to the same office. The provision for proposed amendments is made much more stringent than formerly. One of the principal features in the amended by-laws is the provision for a nominating committee, which now consists of eight members appointed by the president, with the president ex-officio. Two of these members shall be past-presidents, two shall be members of the executive committee and four shall be non-office-holding members, thus giving the largest representation on the committee to the general membership of the society. It was unanimously voted that the thanks of the society be tendered to Messrs. Jones, Dunn and Williams for their able and valuable services.

The election of officers resulted as follows:—

FRANK J. SPRAGUE,
The new President of the Society.

For president, Frank J. Sprague.

Vice-presidents, C. G. Young, re-elected; E. H. Mullin, re-elected; F. C. Bates, re-elected; Albert F. Ganz, Louis B. Marks, W. S. Rugg.

J. J. CARTY,
The Retiring President of the New York Electrical Society

Secretary, George H. Guy, re-elected.

Treasurer, Henry A. Sinclair, re-elected.

After the business meeting the society was welcomed by Mr. John W. Lieb, Jr., president of the Electrical Testing Laboratories. Mr. Leib gave a short history of the foundation of the laboratory, which has developed from a lamp testing bureau, founded by the Association of Edison Companies, to its present extensive and complete equipment. They had endeavored to make it a place where, at

E. H. MULLIN,
Re-elected Vice-President.

a very reasonable expense, anyone could come and be sure of having tests made with accuracy and dispatch. Since the laboratory has been opened, all kinds of electrical tests have been conducted, especially on the photometric value of arc lamps, breakdown tests of insulating material, the effect of the distribution of light due to shades and reflectors, the meter tests, the standardizing of instruments, the preparation of photometric standards, etc.

Mr. Wilson S. Howell, manager of the laboratories, gave a short address on the "Importance of Testing." Mr. Howell showed that the matter of testing was equally important to the manufacturer and to the purchaser. Among instances given of complete testing equipments, he mentioned those of the Pennsylvania Railroad Company, the Brooklyn Navy Yard, the General Electric and the Westinghouse Companies, and it was demonstrated that the success of all those organizations was due to a great extent to their continuous testing, not only of their own purchases, but also of their own products. The Electrical Testing Laboratories had provided for the general public at a moderate price, the advantages of precision and efficiency, which has been secured in the cases mentioned only at a heavy outlay.

Dr. Clayton H. Sharp addressed the meeting on the "Equipment of the Commercial Testing Laboratory," concluding his address with an exhibition of a number of slides, the most interesting of which were made by a triple oscillograph, showing an alternating e. m. f., and currents set up thereby in an inductance and a capacity in parallel with each other.

After an inspection of the splendid equipment of the laboratories had been made by the visitors, a collation was served.

Trade News

The Shepherd Engineering Co., of Franklin, Pa., have opened a Boston branch in the new Oliver Building at Oliver and Milk streets. Mr. W. N. Clifford is in charge. The company now have, in addition to this and their home offices, branches at Chicago and Philadelphia.

The Illinois Steel Company are pushing rapidly the work of building their great cement plant at Buffington, Ind. Electric power will be furnished from the company's works at South Chicago, 6 miles distant, it being generated at a station adjoining their furnace plant, in which surplus blast furnace gas is used as fuel for boilers operating the dynamo engines. In order to take this power across the Calumet River the company are erecting steel towers on either bank 200 feet high, across which the cable will be stretched at a point sufficiently high to cause no interference with the masts of the tallest vessels. While the expense of building these towers is greater than it would be to pass the cable through a conduit on the bed of the river, the company concluded to use the former method because of the leakage expense that usually attends submerged lines.

The Locke Insulator Manufacturing Company, Victor, N. Y., have placed a contract with Prof. H. B. Smith, of the Worcester Polytechnic Institute, Worcester, Mass., for a 200-K. W. 300,000-volt transformer, which will be the largest very high-potential transformer ever built. though its voltage will be less than that which has been used at the Polytechnic for experimental purposes. The transformer will be built in the Institute shop, which, as is well known, is a successful commercial enterprise.

The Aultman & Taylor Machinery Company, of Mansfield, Ohio, makers of water-tube boilers, have a working exhibit at the St. Louis Fair, consisting of eight 500-H. P. boilers, carrying a pressure of 250 pounds; four 500-H. P. boilers with a pressure of 175 pounds, and eight 400-H. P. boilers also carrying 175 pounds pressure. Three other vertical boilers are of 250-H. P. each. All of the boilers are of the "Cahall" type, are fitted with the company's chain-grate stokers, and together supply over 25,000 horsepower. The company also has a nonworking exhibit in the Palace of Machinery, showing the inside construction of the boilers.

The Canadian Westinghouse Company, Limited, of Hamilton, Ont., have recently closed a contract to furnish the Shawinigan Water & Power Company, at Shawinigan Falls, P. Q., with a 6600-K. W., two-phase, 2200-volt, 3600 alternations, 180 R. P. M. rotating field alternator, for direct connection with water wheel. Two 2200-K. W. oil insulated water cooled transformers, 2200-volt primary, 50,000-volt secondary, are included in this contract.

The Mexican Light & Power Company, Limited, of Montreal, Can., recently placed in the United States an order for copper cable for transmission, which is probably the largest single order for transmission cable ever placed. The order calls for 1500 miles of cable, equal in carrying capacity to No. 000 B. & S. gauge, and weighing approximately 4,200,000 pounds. The cable is to be used on the Nicaxia-Mexico power transmission line, now under construction, and it will be supported on steel towers in spans of 500 feet. The length of the spans, together with the necessity of reducing the dip as much as possible and the high wind pressure to be withstood, made the matter of cables one of considerable importance. The cable was designed by W. G. Clark, of Seattle, Wash., electrical engineer.

The Hartford Blower Company, Hartford, Conn., has received an order from Sargent & Company, New Haven, Conn., for the installation of a system for collecting shavings, sawdust, chips, etc., from wood-working machinery and conveying them to the boiler house. Another order has been received from the Scovill Manufacturing Company, Waterbury, Conn., for collecting dust from crushing machinery. This system of collecting waste has been dealt with in a new catalogue issued by the Hartford Company, entitled "Dust Collecting."

New Catalogues

"Multiple Voltage" is the title of a new bulletin of the Bullock Electric Manufacturing Company, Cincinnati, Ohio, devoted to a system of control for variable speed motors operating machine tools. The system is described with the aid of diagrams showing the connections, and illustrations are given of several installations operated on the multiple voltage system. The controllers used with this system are also illustrated and described, the results of lathe-turning tests with multiple voltage and with rheostatic control are tabulated, and speed and horse-power curves are given of a motor operating on this system.

A new catalogue devoted to engines and boilers has just been issued by the James Leffel & Co., of Springfield, Ohio. It contains illustrations and descriptive particulars and other data of interest to possible purchasers of that kind of machinery.

"Retail Coal Pockets" is the title of a new booklet issued by the Link-Belt Engineering Company, of Philadelphia, Pa. Several illustrations show pockets built by the company, and the standard arrangement of structures and machinery for the re-

tail coal trade is described and shown in numerous diagrams. The same company have also sent out a booklet dealing with the Renold silent chain gear. The method of construction of the chain is shown and described in detail, and the application of the chain drive to various classes of work is likewise illustrated.

Electric motor-driven air compressors, stationary and portable, are described in a new pamphlet issued by the National Electric Company, of Milwaukee, Wis. Illustrations are given of the machinery, together with tables of dimensions and capacities, and wiring and piping diagrams to show the arrangement of motor and compressor connections.

"Dragon" Portland cement is the subject of a new publication sent out by the Lawrence Cement Company, of Siegfried, Pa. The booklet contains a variety of reports of tests of "Dragon" cement, as well as some general information of use in cement work.

A catalogue supplement recently issued by Arthur Koppel, of New York, manufacturer of industrial, narrow and standard gauge railway materials, illustrates a partial list of Baldwin locomotives, which the firm has arranged to handle in connection with its railway supply business.

Rubber tires are illustrated and described in a catalogue sent out by the India Rubber Co., 16 Warren Street, New York. The pamphlet includes several types of tires, both solid and pneumatic, now in general use on automobiles, bicycles, carriages, etc.

Pumping machinery made by Fairbanks, Morse & Co., Chicago, Ill., is illustrated and described in a new catalogue issued by that firm. The booklet gives particulars of various types of steam and power pumps.

The Curtis steam turbine is the subject of a new catalogue sent out by the General Electric Company, Schenectady, N. Y. The turbine in detail and assembly is fully illustrated and described in this pamphlet, and several diagrams are given showing its advantage in the economy of floor space and head room over the reciprocating engine. Another catalogue by the same company is devoted to lightning arresters.

The latest bulletin of the Arnold Electric Power Station Company, Chicago, Ill., is devoted entirely to a description of the Baring Cross shops of the St. Louis, Iron Mountain & Southern Railway. The specifications for the air, power, water, lighting and heating systems in the shops were drawn by the Arnold Company, who also had the contract for the installation. A similar bulletin has been issued describing the Omaha shops of the Union Pacific Railroad.

The use of corrugated steel bars as in steel-concrete construction is profusely illustrated in a catalogue issued by the St. Louis Expanded Metal Fireproofing Company, of St. Louis, Mo. Formulæ also are given for calculating the strength of steel-concrete beams, and tables likely to be of use in designing work of this class.

A series of ten pamphlets has been issued by the Electric Controller & Supply Company, of Cleveland, Ohio, each pamphlet devoted to a special line of product. Electric railway supplies are embraced in the first five books, the remainder dealing with lifting magnets, magnetic clutches and other electrical appliances for industrial use.

Mechanical draft apparatus is described and illustrated in a new catalogue prepared by the Hartford Blower Company, Hartford, Conn. The book deals with a variety of apparatus for forced and induced draft for boilers as well as blowers for ventilation and similar work.

The new Hamilton-Corliss vertical cross-compound engine, of the type on exhibition at the St. Louis Exposition, is illustrated and described in an attractive catalogue just issued by the builders, the Hooven, Owens, Rentschler Company, of Hamilton, Ohio. General and sectional views are shown as well as details.

Mine haulage and the adaptation of the electric locomotive to this class of work, is discussed in a new publication issued by the General Electric Company, of Schenectady, N. Y. The little volume contains abstracts from various articles on electric mine haulage, and is well illustrated with views showing different forms of electric mine locomotives.

Advance sheets, embodied in pamphlet form, of a new catalogue on air compressors have been issued by the Ingersoll-Sergeant Drill Company, of New York. The pamphlet contains illustrations of many of the various types of compressors, accompanied by tables giving dimensional data for each class. Several views of installations are shown, and a short treatise on heat and pressure curves for compressed air is given. Tables of air flow in mains, and of capacity required to operate hoisting engines, rock drills and pumping plants, are also contained in the pamphlet.

The advantages of the Nernst lamp are set forth in a new pamphlet just issued by the Nernst Lamp Company, of Pittsburg.

Electric mine locomotives for gathering purposes are illustrated and described in a new pamphlet sent out by the Jeffrey Manufacturing Company, of Columbus, Ohio.

A Patent Office for China

IN the treaty which has just been ratified between the United States and China, the United States Government agrees to allow subjects of China to patent their inventions in the United States and protect them in the use and ownership of such patents. The government of China also agrees that it will establish a patent office. After this office has been established and especial laws with regard to inventions have been adopted, it will thereupon, after the payment of the prescribed fees, issue certificates of protection, valid for a fixed term of years, to citizens of the United States on all their patents issued by the United States in respect to articles, the sale of which is lawful in China, which do not infringe on previous inventions of Chinese subjects, in the same manner as patents are to be issued to subjects of China.

A remarkable instance of the durability of electric pumps is reported from South Africa, where, in the mining districts, electricity and compressed air are fighting for supremacy. It was after the cessation of hostilities that the two shafts of the Knights Deep mine were found to be flooded out. The plant and other apparatus had been left just as they were before the war broke out, and the electric pumps and cables which were used at the mine had been under water for quite two and one-half years. Notwithstanding, the motors were brought out, dried and set to work again. The firm who supplied the motors is not mentioned, but their name deserves to be placed on record.

The acceptances of membership in the International Electrical Congress of September 12-17, in St. Louis, number 1702, and over 160 specially invited papers are promised in all.